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HIGHLIGHTS THIS MONTH

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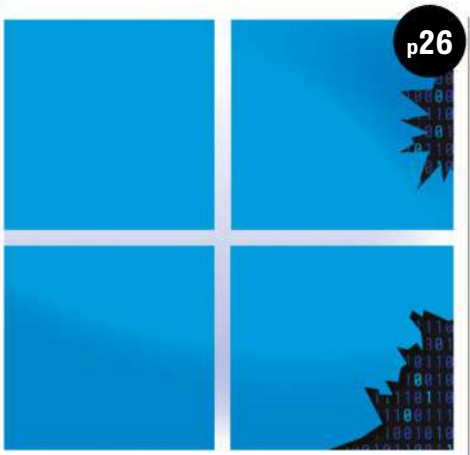
REVIEW OF THE MONTH

Dell Pro 13 Premium

This year marks a new beginning for Dell as the company switches to what it believes is a simpler way of branding. Whether you're buying a monitor, laptop or PC, its consumer products will be called Dell, its business line-up Dell Pro and its workstation-level equipment Dell Pro Max. Within the consumer and business lines, adding Plus or Premium indicates better and best quality. This month we take our first look at one of the refreshed products, the Dell Pro 13 Premium laptop. So a top-end business model. We're still not totally convinced by this rebranding, but if all the new products are this good we're not complaining.



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Take control of how Windows looks with one of the truly brilliant custom launchers available – we test ten to find the best – or using the tools that Microsoft hides away.

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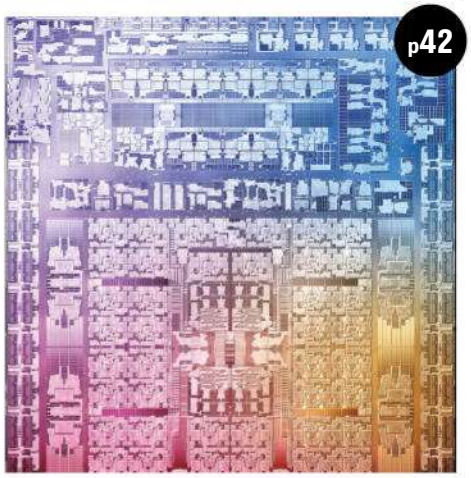
Affinity Designer is a powerful and affordable rival to Adobe Illustrator and CorelDRAW. Tap into its power by following our top five insights on how to use it.



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Processors have never been more powerful, or more confusing. In the first of a two-part guide, we explain the fundamentals from die size to the rise of chiplets.

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PERSON OF THE MONTH

Sebastian Raschka

Who better to explain how LLMs reason than an LLM research engineer? That's why we turned to Sebastian Raschka, who's also written a book on the subject, for a detailed explanation that definitely involves no generative AI.

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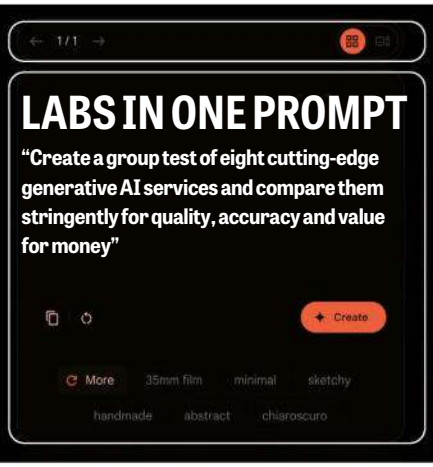
LABS IN ONE PROMPT

"Create a group test of eight cutting-edge generative AI services and compare them stringently for quality, accuracy and value for money"



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p52 **Double up on your screen real estate with the impressive Asus Zenbook Duo**

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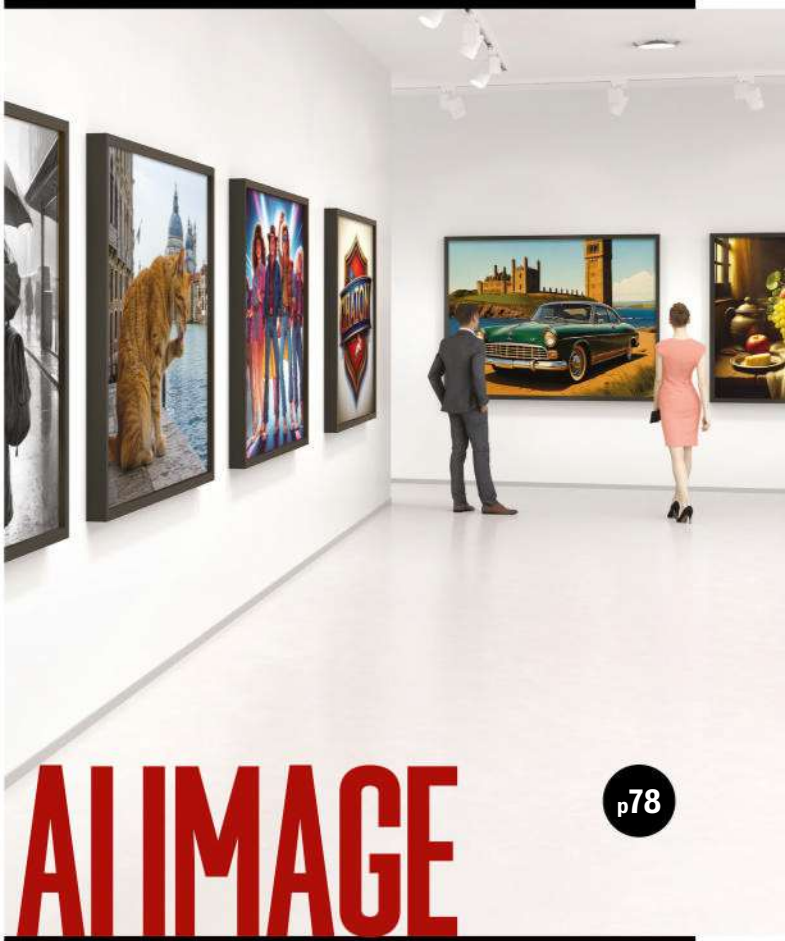

AI IMAGE GENERATORS

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An explosion of AI image generators has invaded our lives, but which ones are best for personal and business use? We put eight to a thorough test in order to find out.

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I went to Barcelona and all you get is this lousy column

Along with receding hairlines and exercise-resistant paunches, nothing gives away the passage of time more than the words that escape our mouths. That moment in the pub when you realise you've been talking about mortgage rates for the past five minutes, or shared with a glassy-eyed acquaintance exactly how much pension pot money you need to afford your lavish retirement. Although over time I've downgraded my idea of "lavish" from two annual foreign holidays to an occasional takeaway.

Now I have another giveaway to add to the list: how you attend technology trade shows. Back in the days when I could fit into jeans that didn't include "stretch" cotton, I spent my days chasing the latest gadgets and my nights chasing bartenders. To serve me drinks, you understand, nothing sinister.

This year my visit to MWC Barcelona was different. Don't misunderstand me: I fondled my fair share of shiny new products, as revealed on p12, but it appears that I'm long past the point where I can be excited by phones.

I tried. I visited the show's biggest, glitziest stands and tried the latest wares from the biggest, glitziest names in Android handsets. But as each enthusiastic demonstrator showed me what their particular rectangle of glass and metal could do, I stifled an inward yawn. It's simply not interesting, and the reason it's not interesting is that it's going to make a big fat zero difference to our lives.

But here's the rub. The other side of MWC, the one that garners no headlines, is about infrastructure. Stay with me here, because you'll want what these organisations have to offer: in the future, it's photonics rather than electronics that will allow you to watch your favourite football team from 17 different viewpoints and snap between them. Next-generation networks spell the end of spinning logos waiting for content to load and could transform, yet again, our economy. It turns out that near-zero lag means new ways to make money.

All this groundwork is being done by the insanely boring-sounding IOWN Global Forum, and the 30-minute conversation I had with one of its leading members – the not at all boringly named Gonzalo Camarillo, who literally wrote the book about SIP in its early days – was one of the best I had at the show.

Then there was my chat with Phil Mottram, who heads up HPE's Intelligent Edge division. Quite aside from a vital discussion about the best pubs in London, he proceeded to give me a lesson on the growing importance of servers at the edge of our telephone networks. I realise everyone is sick to the teeth of AI, but it's inveigling its way in there, too.

And how, after a day of hard-hitting interviews and floor-show-trudging, did I celebrate? Did I go wild and drink my bodyweight in sangria? No. I thought to myself, hmm, this is a great opportunity to grab an early night so that I can get up early tomorrow morning and do it all over again. I know, it's sad. And I did explore Barcelona a little, I promise. But it also means that all the money I would have spent on strong lager and nightclub entry fees can go into that pension pot instead. Although first I need to buy some new jeans, because oddly it seems that these ones don't fit me any more.

Tim Danton
Editor-in-chief

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Dave Mitchell
If you're currently shelling out hundreds of pounds per year for cloud-based storage, Dave's review of business NAS drives could add to your data security and save you money. Find out how from p96.

Jon Honeyball
You may not remember Microsoft's Barney, who's been part of Jon's testing setup for two decades, but it turns out that he was a harbinger of things to come – if Apple has its way. See p110.

Steve Cassidy
When Steve is turned down for a business account, he discovers that it's due to a company he registered almost three decades ago. Data says no, and that's not good enough. Turn to p120.

Rois Ni Thuama
There's a tug of war going on between online protection of children and our privacy, and this lawyer thinks it should be worked out using technology rather than in the courts. See p116.

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On p22, Barry Collins shares his usual forthright views on why people are making too much of a fuss about transferring ebooks to their Kindles. It made us wonder, how many books our contributors have on their Kindle, if they have one at all...

"Okay, I'm a little surprised to find I have over 300 books sitting on my Kindle. And apparently I've read most of them, even if I can't remember doing so. Looks like I know what luxury to bring with me to the desert island when Lauren comes calling."

"132, read mostly on Chromebook rather than my vintage Kindle 2nd Gen. I review books, and nowadays always ask the publisher for a Kindle edition as well as paper, because its note-taking and search facilities have become indispensable."

"Amazon tells me the total is 125, but I've only read a minority of them – sometimes I just like to shop."

"48. And according to my Reading Insights, I've read for 134 weeks straight and 44 days on the spin. Where's my gold star?"

"498, apparently, but all the books I've bought recently have been on Kobo."

"No Kindle here. When I read for leisure, I want PAPER, whether it's VS Ramachandran on neurology or the Saab 9-5 workshop manual, which has been prominent on my shelves for the last few months."

"I have one 'book' on my Kindle, *The Harvard Classics Collection*, which is 51 volumes weighing in at over 40,000 Kindle pages. It's mainly awful but apparently it's good for me. Ironically, the Kindle file is so large that it won't run on my Kindle, so I have to use an iPad."

"About a dozen. I carry my Kindle with me on trips, but I can't remember the last time it was charged up. I shall do better for my trips over the next weeks!"

"60. Kindles are great if you're stuck, but they suck the joy out of reading."

"50+ ranging from Russian revolutionary political tomes to throwaway thrillers."

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Briefing

Background and analysis on all the important news stories

The government's powers have come under attack from all sides

Apple stand-off could lead to landmark ruling

Row with Apple provides first big test for UK snooping law

The British government's ability to intercept the communications of its citizens is facing a landmark legal test following a public dispute with Apple.

In February, Apple announced that it would be withdrawing its Advanced Data Protection (ADP) tool in the UK, which allows customers to encrypt the contents of their iCloud storage, after the company was issued with a secret order forcing it to hand over customer data.

Apple said it would rather remove the tool for all UK consumers than break encryption to appease the UK government's request. "As we have said many times before, we have never built a backdoor or master key to any of our products, and we never will," Apple said in a statement to the BBC.

Subsequently, Apple has decided to take the fight to the government, launching an appeal to the Investigatory Powers Tribunal, an independent judicial body that handles complaints against the security services, in what could be a landmark ruling for the privacy of British citizens.

Law finally bites

The British government's ability to demand even encrypted data from tech companies has been on the statute book for a number of years, as part of the 2016 Investigatory Powers Act. The government can demand data via a legal instrument known as a Technical Capability Notice (TCNs).

"This is the first public example that we have of such a TCN being issued," Rebecca Vincent, interim director of civil rights group Big Brother Watch, told *PC Pro*. "But of course, everything is so shrouded in secrecy that we really don't have a

> Everything is so shrouded in secrecy that we really don't have a way of knowing if the government has issued other such orders

way of knowing if the government has issued other such orders."

TCNs are not generally made public. They require sign-off from the Home Secretary and approval from a judicial commissioner, both of whom assess the necessity and proportionality of the order, and the recipients are generally prohibited from disclosing their contents or that the order even exists in the first place.

Efforts have been made in the past to find out how often the government issues TCNs, but they've borne little fruit. Back in 2020, Liberal Democrat peer Lord Scriven asked the government how many TCNs had been issued and whether they had had the "desired effect".

Baroness Williams of Trafford, answering for the Conservative government of the time, replied that "for reasons of national security, it would not be appropriate to disclose the number of Technical Capability Notices, or the specific circumstances in which they may be issued".

Crunch time

Rebecca Vincent says Apple's appeal hearing with the Investigatory Powers Tribunal could be pivotal for the rights of UK citizens. "The outcome of that [appeal] will have huge implications for what happens next, not only for Apple, but in general, because I think if the government wins in tribunal, then we will see other examples follow with similar orders to other platforms," she said.

"The impact, of course, is on all internet users in the UK," she continued. "I think we could see a very quick escalation where other tools that we use for messaging or communications, or other areas of our work or personal lives can be very quickly compromised."

However, it may not be immediately clear what the outcome of Apple's appeal is, with the hearing likely to take place behind closed doors. Only if Apple continues to pursue the case may we finally get a public ruling on the legality of demanding companies break their own encryption. "If it goes to the Court of Appeals, if it went all the way to the Supreme Court, then it does have the potential to be that emblematic case," said Vincent.

In the meantime, with Apple threatening to leave all UK customers without access to encrypted iCloud storage, critics claim the government's actions have simply made security weaker for all.

"The Home Office's actions have deprived millions of Britons from accessing a security feature," said James Baker, platform power programme manager at the Open Rights Group, in a statement issued after Apple pulled ADP. "As a result, British citizens will be at higher risk of their personal data and family photos falling into the hands of criminals and predators."

Angry Americans

It's not only the privacy groups who are upset, either, but the US government too. News of the TCN being applied to Apple drew a sharp response from Tulsi Gabbard, the new US director of national intelligence. In a letter to the UK government, she called the move a "clear and egregious violation of Americans' privacy and civil liberties", because the UK government has the power to demand any data, not just that concerning UK citizens.

Gabbard's letter followed strong condemnation from two democratic senators, who called on the US Department of Justice to review the notice, arguing that it "undermines US law, public policy, and information security by requiring US companies to take such reckless action as undermining encryption for all users globally".

> British citizens will be at higher risk of their personal data and family photos falling into the hands of criminals and predators

The UK government continues to insist the measures in the act are proportionate. In a response to a Liberal Democrat question about Apple's decision to withdraw ADP in late February, minister of state for security Dan Jarvis replied that "the suggestion that privacy and security are at odds is not correct; we can and must have both. The Investigatory Powers Act contains robust safeguards and independent oversight to protect privacy and ensure that data is obtained only on an exceptional basis, and only when it is necessary and proportionate to do so."

Openreach rolls out symmetric gigabit – at a price

Huge upload speed increases arrive for a three-figure monthly fee

Openreach has announced that it is to begin selling symmetric gigabit connections for consumers and businesses. But customers will be paying well over three figures a month for the privilege, and it's not available in many areas.

The new speeds – only available to properties in a BDUK Type C area, which are mainly hard-to-reach rural locations – will arrive at a wholesale cost to broadband providers of £1,200 per year, plus a connection fee of £123. That boils down to £100 per month, before VAT and the broadband provider's margin are taken into consideration, which means lines are likely to cost at least £150 per month for consumers.

For comparison, Community Fibre charges as little as £25 per month to consumers for symmetric gigabit connections, while Zen Internet sells symmetric 2.3Gbits/sec connections based on the CityFibre network for £55 per month. Both of those providers have a much smaller nationwide footprint than Openreach.

Openreach's symmetric gigabit connections will come at quite a cost

Openreach declined to comment on why its lines are so comparatively expensive, but it's worth pointing out that the so-called altnets (alternative fibre providers) are still trying to scale their networks. As such, they may be selling connections at below cost to attract users.

Broadband providers suspect the robust pricing is to prevent cannibalising Openreach's own Ethernet lines. "The saving would not be sufficient to cause a business to cancel the Ethernet," said Alex Bloor, general manager at A&A. "That'd be my guess as to why it's been pitched at that price. Because if you're paying even £250 a month or £300 a month for an Ethernet service – which, by the way, will have much better SLA and stuff like that – you're probably unlikely to save the two-and-a half-grand a year to downgrade to a broadband service, even if it notionally is symmetrical."

Bloor thinks the gigabit broadband lines will appeal to small businesses, even at that price. He envisions businesses "connecting up offices with this, especially where they've got multiple offices and they need interconnectivity between them. That's where symmetrical really comes into its own, because... if you've got one office talking to the other, there'll be roughly a balance of traffic in both directions."

Zen Internet say it's not even going to offer the new tier. "As things stand, we have no plans to launch the Openreach symmetric gigabit offering mainly due to availability and price," said the company's connectivity portfolio manager, Andrew Sayle. "As the product is limited to BDUK Type C contract areas, it is inaccessible to most of our customer base." He added that he hoped the initiative would give Openreach the confidence to deliver more such products "at an affordable price".

Best of MWC Barcelona 2025

This year's show was packed to the brim with exhibitors, visitors and product launches, with this selection cutting through the noise

PC PRO ★ BEST OF MWC 2025 ★

HMD Fusion X1

Smartphone brands have previously tried to protect children by bolting controls and digital health features on top of their existing interfaces, but the HMD X1, a partnership between HMD and kid-friendly tech brand Xplora, is designed from the ground up to help young people grow into the smart device world. It give parents granular control over app permissions and approved contacts, direct access to the phone from a parent device, plus options for tracking and concentration modes. Meanwhile, a 108MP camera, 5,000mAh battery and a variety of case options may yet win over teenagers. Expected to launch this year, but the price and monthly subscription cost for services are yet to be confirmed. RICHARD PRIDAY

Dell Pro Rugged 13

It wasn't only Dell's Pro 13 Premium I got my hands on this month (*see p46*); I also spent some quality time with its rugged sibling at Dell's MWC stand. Despite the Dell Pro Rugged 13's relatively slim dimensions – 324 x 220 x 36.5mm (WDH) – and 2.4kg starting weight, this is a fully rugged system to rival a Panasonic Toughbook or Getac notebook, and its 13.3in panel is notably punchier than those in its rivals. You also benefit from Intel Core Ultra chips – first-generation, so no NPU – and excellent customisation options. Prices are suitably steep, starting at around £3,000 exc VAT, and it's available to buy now. TIM DANTON

Lenovo Magic Bay Dual Display Concept

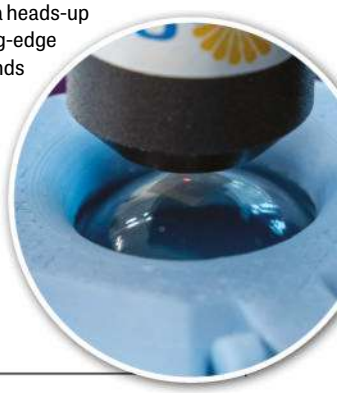
If there's one thing I can guarantee when I head to a tech show, it's that someone will be trying to add extra monitor space to laptops. Lenovo took two bites at that cherry at MWC, accompanying the frankly weird "Codename Flip" concept opposite with the far more prosaic solution you see to the right. That pair of screens on either side fits on to the rear of the ThinkBook via magnets, using Lenovo's Magic Bay connector – this already exists, but until now has been restricted to boring cameras and ring lights. This solution – still a concept, but it looked close to production quality – makes much more sense. Lenovo also showed a single-monitor extension, which is more sensible still. TIM DANTON

Lenovo Yoga Solar PC

A laptop that can charge from sunlight? Why didn't someone think of making this sooner? Lenovo's Yoga Solar PC is essentially a slim Yoga laptop with a solar panel built into the back of the display, and can generate a full hour's charge from 20 minutes in direct sunlight. Smart power delivery software prioritises electricity from the solar cells over the existing charge to preserve your battery, and Lenovo claims that the laptop can even sustain charge passively in low-light conditions thanks to the incredibly high efficiency of the solar panel. This is very much a concept device, though, with no planned release date. DARREN ALLAN

Xpanceo Biosensing smart contact lens

Surely this is the future? Not only do these AR contact lenses include a heads-up display, but also cutting-edge biosensors. It sounds like a James Bond gadget until you hear that these sense glucose and hormone levels, providing a way to monitor your eyes' health and detect early signs of glaucoma. Dubai-based Xpanceo



showed off a trio of such lenses at MWC, having partnered with universities and research centres in Spain, Sweden, the UK and France. But it's not just about health; other concepts included contacts for data reading that "enables real-time data transfer from the contact lens to a companion device". Look at something and it will send data straight to your phone (or Q Branch for analysis). The future is now. STEPHEN WARWICK

Nubia Flip 2 5G

The Nubia Flip 2 5G is a flippable phone with a difference: it's affordable. Well, quite affordable, with a price of €699 in Europe (we await UK prices and availability). This is the successor to last year's Nubia Flip 5G, which cost €599, and boasts a lighter, more durable design, a more powerful MediaTek Dimensity 7300X chipset, and – surprise! – a suite of AI features including real-time call translation and Google Gemini. Another reason for the price rise is a bigger 3in OLED on the front to accompany the main 6.9in 120Hz display. AXEL METZ

Lenovo ThinkPad X13 Gen 6

Compared to the ThinkBook "Codename Flip" and Yoga Solar PC, the fact that Lenovo launched seven ThinkPad and two ThinkBook updates at MWC seems almost too boring to mention, but frankly I think it will sell rather more of the latest ThinkPad X13, now weighing 933g despite including your choice of the latest Intel vPro and AMD Ryzen AI Pro chips. It goes on sale in June with prices starting at €1,399. Lenovo also announced its first ThinkPad 2-in-1, the T14s, which will cost from €1,649 when it goes on sale in the same month. TIM DANTON

Lenovo ThinkBook "Codename Flip"

Yes, we've all seen folding laptop screens before, but what about one that folds backward? That's exactly what Lenovo's "Flip" concept does, letting you unfurl the display to create a massive vertical-orientation screen, then fold it back down to create a laptop with displays on both sides of the lid. It packs other nifty features, too, including a light-up number pad and media controls that are both concealed in the touchpad. Questions remain over how to protect the exposed screen when travelling, and exactly how much it will cost, but the biggest one is whether it will move from concept to reality. WAYNE WILLIAMS

Samsung A56 5G

Excitement for Samsung's mid-range A-series often gets lost in the hype for its flagship S-series, but the Galaxy A56 5G deserves attention this year for opening up Galaxy AI – or at least a trimmed-down version of it (called Awesome Intelligence) – to a whole new price range. Hardware-wise, the phone includes a vibrant 6.7in OLED display, still-powerful Samsung Exynos 1580 chipset and a decent three-lens camera setup. Put simply, the A56 5G is the obvious option for Samsung fans who don't need wafer-thin display bezels and benchmark-breaking power. AXEL METZ

Opera Browser Operator

Opera is building agentic AI directly into the browser. This, claims the company, not only makes it faster than rivals from OpenAI et al – which in effect have to direct your queries via a virtual machine, with consequent security implications – but also means you can make even more complex demands. You may already be familiar with Opera's Aria AI, built into Opera One R2 and Opera Air, and this works similarly: activate Operator, enter your prompt and let it loose. For instance, when browsing on a shopping site, tell it to buy ten pairs of socks and watch it go. Operator is currently available as a preview, but expect it to appear as part of an AI feature drop soon. JASON ENGLAND

Honor Watch 5 Ultra

The Honor Watch 5 Ultra is that rare thing: an affordable, system-agnostic smartwatch that packs a big battery life. To get a titanium shell, 1.5in AMOLED screen and 15 days of life in a smartwatch that works well with both Android and iPhone handsets, for around the same price as an Apple Watch SE 2, is excellent value. Honor hasn't reinvented the wheel here, but the €279 price (there's no UK price or on-sale date yet) is as aggressive as we'd expect. STEPHEN WARWICK

The A-List

The best products on the market, as picked by our editors

PC PRO A-LIST

PREMIUM LAPTOPS

Apple MacBook Pro M4

M4 beast from £1,599

from apple.com/uk

This M4 update to the already brilliant MacBook Pro line is an easy recommendation, so the big question becomes do you choose the 14in version from £1,599 or 16in from £2,499? And then how much do you upgrade, as Apple isn't afraid of high prices. But whatever you choose should last for years, and look great while it's doing it.
REVIEW **Issue 364, p50**

NEW ENTRY

Apple MacBook Air M4

If you don't need the all-out power of the Pro, this is a brilliant, cheaper alternative despite the unchanged chassis and screen. **13in from £999, 15in from £1,199 from apple.com/uk**
REVIEW **Issue 368, p54**

Asus Zenbook S 14 OLED

Asus pairs a Core Ultra 9 288V with a 72Wh battery to produce a laptop that lasts almost 20 hours on a charge. What's more, this 1.2kg machine looks (and feels) the business. **From £1,750 from scan.co.uk**
REVIEW **Issue 362, p46**

Asus ProArt PX13

With AMD's new Ryzen AI 9 HX 370 inside, this 1.4kg compact powerhouse offers incredible amounts of power. Add a fantastic OLED screen and RTX 4070 graphics and it's a winner. **From £2,000 from uk.store.asus.com**
REVIEW **Issue 361, p50**

BUSINESS LAPTOPS

NEW ENTRY

Dell Pro 13 Premium

Sheer quality from £1,452 exc VAT

from dell.com

Dell's business laptop series has a new name, but its commitment to build quality and astonishing levels of configuration remain the same. Here, you benefit from a 1.1kg weight and 24-hour battery life, with Intel's 200V vPro series there for easier remote management. Just make sure you avoid the cheap screen option.
REVIEW **Issue 368, p46**

Lenovo ThinkPad X1 Carbon Gen 12

The X1 Carbon range has stepped up a gear thanks to Intel's Core Ultra chips, and Lenovo matches it with the stunning build quality and keyboard you'd expect. **From £1,375 from lenovo.com**
REVIEW **Issue 358, p58**

Lenovo ThinkPad T14s Gen 6 (Snapdragon)

There's no better laptop if you want to try out Snapdragon, thanks to its combination of build quality, speed and battery life. **£1,500 exc VAT from lenovo.com**
REVIEW **Issue 360, p56**

HP OmniBook Ultra Flip

A top-quality 2-in-1 with a terrific 14in OLED panel, great build quality and superb battery life thanks to Intel's latest generation Core Ultra 7 processors. **From £1,699 from hp.com**
REVIEW **Issue 365, p46**

COPILOT+ PCs

Asus Zenbook A14

Sub-1kg style for an affordable £1,100

from uk.store.asus.com

It says something about this affordable and super-slim laptop that with its 14in OLED panel it could easily take pride of place in our premium laptops category. It has all the performance most people need and fantastic build quality.
REVIEW **Issue 367, p58**

Lenovo Yoga Slim 7x Gen 9

A Snapdragon X1E-78-100 makes this a nippy Copilot+ PC, and the battery lasts over 16 hours despite the demands of its top-quality 14.5in OLED screen. **£1,350 from lenovo.com**
REVIEW **Issue 361, p57**

Microsoft Surface Laptop, 7th Edition

The poster child for Copilot+ PCs offers quality, great looks and staggering battery life. **From £1,049 from microsoft.com**
REVIEW **Issue 360, p50**

Asus Zenbook S 15 OLED

With a price drop to £1,200 this 15.6in laptop becomes a viable competitor to the Yoga Slim 7x if you need a bigger screen. **£1,200 from uk.store.asus.com**
REVIEW **Issue 359, p52**

EVERYDAY LAPTOPS

Acer Aspire 14 A14-51GM

Compact power for £850

from acer.com

Want gaming power? Buy the version with RTX 2050 graphics for £850 (part code NX.KSVEK.005). Just care about value? Get a Core 5 processor and integrated graphics for £600 (part code NX.KRWEK.00B). Whichever you choose, it's a staggering laptop for the price.
REVIEW **Issue 359, p82**

Asus Zenbook 14 OLED (UX3405)

If you can stretch past £1,000, this is a top-quality Core Ultra laptop with a superb 120Hz screen and great battery life. **From £1,099 from uk.store.asus.com**
REVIEW **Issue 359, p58**

Framework Laptop 13 (DIY Edition)

With a competitive price, modular approach and easy-to-repair ethos, you can pick and mix your perfect 13in laptop. **From £779 from frame.work**
REVIEW **Issue 360, p58**

Huawei MateBook D16

It's big and certainly not bashful, packing an Intel Core i9 chip and a high-quality 16in panel – and surprisingly good battery life, too. **£1,000 from huawei.com**
REVIEW **Issue 359, p87**

CHROMEBOOKS

Samsung Galaxy Chromebook Plus (2024)

Core 5 power for £749

from samsung.com

The first truly desirable Chromebook since the Pixelbook, this is a top-quality laptop from the all-metal chassis to the 15.6in Full HD OLED screen. And thanks to Intel's Core 5 120U processor, it's fast enough to last for years.

REVIEW **Issue 364, p65**

Acer Chromebook Plus 515

This Chromebook Plus laptop is all about value. With strong speeds thanks to Intel's Core i5-1235U processor, and a good-quality 15.6in panel with a 1,920 x 1,080 resolution, Asus' Chromebook Plus 515 is ideal for families, students and business users, providing mobility isn't your main priority as it isn't particularly light at 1.7kg. **£429 from currys.co.uk**

REVIEW **Issue 356, p82**

Acer Chromebook Spin 714

If you're looking for a convertible, this is the best choice around. Others may beat the 12th gen Intel Core i5 we tested for performance, but for features, design and bang for buck you won't find any laptop that can match this 2-in-1 for the money.**£799 from currys.co.uk**

REVIEW **Issue 356, p83**

MINI PCs

Apple Mac mini M4

Little monster from £599

from apple.com/uk

This is a big and timely update for the Mac mini, with a much smaller (and squarer) design that's easy to tuck behind a screen. But what lifts it above the pack is the astonishing power of the M4 and M4 Pro chips, with barely any cooling required. As ever with Apple the upgrade costs are high, but at least its starting price is reasonable.

REVIEW **Issue 364, p44**

Geekom A6 Mini PC

The Geekom A6 Mini PC steals the A8's place on our A List thanks to its sheer value for money. The A6 costs £220 less but doesn't compromise on quality or connectivity, and while the Ryzen 7 6800H is a step down from the Ryzen 9 8945HS in the A8, it remains a superb performer.

£499 from geekom.co.uk

REVIEW **Issue 367, p56**

Minisforum Venus UM790 Pro

Ignore its basic looks, for this compact system packs in a fast AMD Ryzen 9 7940HS processor, 32GB of DDR5-5600 RAM and 1TB SSD along with a generous selection of ports, including two USB-C 4 connectors. And the price is super-aggressive.

£549 from store.minisforum.uk

REVIEW **Issue 363, p91**

ENTHUSIAST PCs

NEW ENTRY NEW ENTRY

Scan 3XS Edge iCue

Silent but deadly fast for £2,800

from scan.co.uk

With the RTX 5080 comes a refresh of best enthusiast PCs. The Scan is a shade slower than its Ryzen 9 9800X3D rival from Wired2Fire, but even at full pelt it remains astonishingly quiet.

REVIEW **Issue 367, p50**

CyberPowerPC Infinity Z890 Air

Don't have the money for the Scan? How about saving £900 on this well-built, compact PC based around a Core Ultra 7 265KF processor and Nvidia's RTX 5070 graphics? Upgrade to 5070 Ti for £150. **£1,900 from tinyurl.com/368cyberpower**

REVIEW **Issue 368, p61**

PCSpecialist Hydra R60S

This compact PC makes little noise but still packs a gaming and creative punch thanks to RTX 4060 graphics and AMD's older but speedy Ryzen 5 7500F. You can upgrade to an RTX 5070 when budget allows. **£999 from pcspecialist.co.uk/reviews**

REVIEW **Issue 368, p60**

ALL-IN-ONE PCs

HP Envy 34 All-in-One

£2,099 widescreen wonder

from hp.com

Built around a high-quality 34in widescreen – which is perfect for viewing two windows side by side thanks to its 21:9 aspect ratio – this also comes with Nvidia RTX 3060 graphics. We're big fans of the magnetic 16-megapixel camera, too.

REVIEW **Issue 335, p46**

Dell Inspiron 24 All-in-One

Despite being built to hit a price point, the Inspiron 24 All-in-One manages to look classy, include a good-quality, 1,920 x 1,080 24in panel and have enough power to breeze through a typical day's tasks. It even packs mod cons such as a 720p webcam. Superb value for money.

From £599 from dell.co.uk

REVIEW **Issue 350, p47**

Apple iMac M4

Anyone hoping for a 27in iMac will be disappointed, but everyone else should be delighted by this M4-powered all-in-one with its 24in 4,480 x 2,520 IPS panel. It's fast inside and out, too, with Thunderbolt 4 and Wi-Fi 6E both part of the package. **From £1,299 from apple.com/uk**

REVIEW **Issue 364, p48**

CREATIVE WORKSTATIONS

Armari Magnetar M64T7-AW1650G4

Threadripping power for £8,329 exc VAT

from armari.com

AMD's Ryzen Threadripper 7980X is the star of this particular show, dominating our benchmarks with the help of 128GB of RAM, two 2TB Crucial PCI-E 5 drives in RAID0 configuration and AMD's Radeon Pro W7800 professional GPU. And it's all wrapped up in a custom Armari case with liquid cooling.

REVIEW **Issue 361, p92**

PCSpecialist Quantum Goliath R

Extracting maximum power from its budget by opting for consumer components with professional levels of power, this well-thought-out workstation couples Intel's Core i9-14900KS with RTX 4090 graphics to tremendous effect. **£3,750 exc VAT from pcspecialist.co.uk/reviews**

REVIEW **Issue 361, p89**

Scan 3XS GWP A1-TR64

A more balanced offering than Armari's Magnetar, Scan mixes a Threadripper 7970X with Nvidia RTX 5000 graphics – and a stunning supporting cast of components with an equally stunning case. Perfect for real-time viewsets and GPU accelerated computation.

£7,917 exc VAT from scan.co.uk

REVIEW **Issue 361, p94**

TABLETS

NEW ENTRY

Apple iPad Air M3

Languid power from £599

from apple.com/uk

It's hard to be too excited by this update as it's exactly the same design but with an M3 chip inside. But when the original was so damn good, whether in 11in or 13in variants, and Apple Intelligence is thrown in, it remains the best choice for the vast majority of tablet buyers.

REVIEW **Issue 368, p56**

Apple iPad Pro M4

The best tablet in the world becomes even better thanks to Apple's stunning M4 chip, a gorgeous OLED screen and the must-have accessory: the all-new Pencil Pro. But it comes with an obvious downside of cost, with the cheapest 13in incarnation costing £1,299. **From £999 (11in, 256GB) from apple.com**

REVIEW **Issue 358, p48**

OnePlus Pad 2

Last year the OnePlus Pad took its place alongside Apple's iPads on the A List – and this year it's done it again, with superb battery life of over 18 hours, a gorgeous design and great power making this new version an even better proposition. All for a price that's exactly right. **£449 from oneplus.com/uk**

REVIEW **Issue 364, p86**

EVERYDAY PHONES

Motorola Moto G54 5G

Great looker for £180

from johnlewis.com

The 6.5in 120Hz IPS display is the G54's standout feature, but it improves on the previous generation in numerous ways while being even cheaper. It's faster, looks better, takes great photos and battery life is strong. You won't find better for less than £200.

REVIEW **Issue 355, p77**

Google Pixel 8a

We're fans of the Pixel 8 but you can save £200 and buy the 8a without missing out on any key features, including its advanced AI skills thanks to the same Tensor G3 chip inside. It's only when you zoom into snaps that you spot the camera quality difference. **128GB, £499 from store.google.com**

REVIEW **Issue 358, p74**

Samsung Galaxy A55

Not the fastest phone on the market, but in return you get a high-quality 6.6in OLED display, excellent battery life and a trio of strong cameras. And you also get four years of feature updates. With a price that significantly undercuts the Pixel 8a, it's great value, too. **128GB, £364 from johnlewis.com**

REVIEW **Issue 358, p77**

PREMIUM PHONES

Samsung Galaxy S25 Ultra

AI in your hand from £1,249

from samsung.com/uk

So good it tempted our reviewer – an iPhone devotee – to move to the other side. That's thanks to the faultless hardware, brilliant photography performance and Samsung's slick AI, not to mention the integrated S Pen stylus. It's not cheap, but you're buying for the long term with seven years of OS updates.

REVIEW **Issue 367, p70**

Honor Magic V3

With the Magic V3, not only does Honor make foldable phones as slim as flagship phones but also as affordable – so long as the £300 discount voucher still applies, as shown in the price here. What's more, the cameras and both OLED panels are superb. **£1,400 after discount from honor.com**

REVIEW **Issue 362, p62**

Apple iPhone 16 Pro

Even without Apple Intelligence, the introduction of a 5x optical zoom, classy 6.3in OLED panel and Apple's ludicrously fast A18 Pro chipset make this the best update to an iPhone Pro for years. And if you need one more reason to buy, how about its much improved battery life? **128GB, £999 from apple.com/uk**

REVIEW **Issue 363, p70**

EVERYDAY MONITORS

Iiyama ProLite XUB3293UHSN-B5

32in 4K bargain, £429

from currys.co.uk

The fact that this 31.5in IPS monitor could compete so well against Eizo's alternative (*see below*) says it all. Great colour coverage in sRGB and DCI-P3, USB-C and RJ45 inputs, plus solid build quality add up to a bargain.

REVIEW **Issue 357, p88**

AOC Q27B3CF2

AOC's relentless focus on value delivers a 27in 1440p screen with a high-quality IPS panel that costs £200 including VAT – and also packs in a USB-C port. Those are almost the only features you get, and the OSD is awful, but at this price we're not complaining. **£200 from amazon.co.uk**

REVIEW **Issue 360, p77**

Acer Verso B277 Ebmiprzxv

This is a basic but high-quality monitor, delivering colourful images across its 27in Full HD diagonal. You don't get USB-C docking, but it includes VGA, HDMI and DisplayPort inputs, plus a two-port USB hub. **£149 from tinyurl.com/357acer277**

REVIEW **Issue 357, p84**

PROFESSIONAL MONITORS

Eizo FlexScan EV3240X

Stunning 4K quality, £1,206

exc VAT from photospecialist.co.uk

With images that whack you between the eyes as soon as you lift it, fully assembled, from its box, this 32in 4K monitor is our top choice pick for anyone willing to make such a hefty long-term investment.

REVIEW **Issue 357, p91**

Eizo ColorEdge CG2700X

A brilliant choice for professional designers, whether working solo or in teams, thanks to its dedication to providing accurate colours across potentially years of life. It's also bang up to date for connectivity, with USB-C and RJ45 making it easy to manage, too. **£2,149 exc VAT from wexphotovideo.com**

REVIEW **Issue 357, p90**

BenQ PD2706U

If you can't stretch to Eizo budget levels then this 4K 27in screen is definitely worth investigating. It has several features aimed at professionals, including a Hotkey Puck to switch between profiles, plus great coverage of the sRGB and DCI-P3 gamuts. **£333 exc VAT from scan.co.uk**

REVIEW **Issue 357, p86**

WEBCAMS

Logitech MX Brio 705 for Business

Consistent brilliance for £219

from logitech.com

Consistent image quality in all lighting conditions coupled with top build quality and nifty features – such as a presenting mode for items on your desk – make this a fantastic all-round choice.
REVIEW **Issue 356, p68**

Logitech Brio 105 for Business

While you can buy 1080p webcams for a third of the Brio 105's price, they won't hold a candle to the Logitech webcam's quality – especially in low-light conditions, such as one candle. It's also easy to manage, for businesses and individuals.
£45 from logitech.com
REVIEW **Issue 360, p77**

Obsbot Tiny 2

This portable 4K webcam delivers for quality, design and sharpness, and it comes with a shedload of advanced features, including dynamic zoom and subject tracking. The only real downside is that it has a price that reflects its premium ambitions.
£329 from amazon.co.uk
REVIEW **Issue 352, p75**

HOME OFFICE PRINTERS

HP OfficeJet Pro 9135e

Do-it-all inkjet for £193

from printerbase.co.uk

This versatile inkjet all-in-one – which includes a 35-page ADF – pumps out high-quality prints at laser-rivalling speeds. Likewise scans and copies. Print costs are reasonable, too.
REVIEW **Issue 365, p85**

Epson EcoTank ET-2865

As usual with ink tank printers, you don't get many frills with the Epson EcoTank ET-2865 (so no ADF or screen). What you do get is incredibly low running costs of 0.5p for colour and 0.2p for mono, plus high-quality prints and scans.
£233 from uk.insight.com
REVIEW **Issue 365, p84**

Canon i-Sensys LBP243dw

Everything you could want from a mono laser printer – it doesn't come with a scanner – the LBP243dw produces excellent results at speed. You also get Wi-Fi and wired networking. **£186 from printerbase.co.uk**
REVIEW **Issue 365, p88**

WORKGROUP PRINTERS

Canon Maxify GX6550

Ink tank all-in-one for £392 exc VAT

from canon.co.uk

Designed to fit in tight spaces, this all-in-one includes a highly effective ADF and backs it up with high-quality prints at 24ipm in our tests. Running costs are superb, too.
REVIEW **Issue 350, p58**

Brother HL-L9430CDN

This laser printer (not an all-in-one, so there's no scanning or copying functionality) is a great choice for a busy office, producing sharp black text and making a good job of colour graphics as well. All while doing so quickly with a competitive price per page. **£415 exc VAT from printerland.co.uk**
REVIEW **Issue 353, p84**

Xerox B315DN

A fine alternative to the Brother and Canon, this mono laser multifunction printer produces superb results at great speed – 27.5 pages per minute in our 50-page test, which includes the spool time. It's similarly quick for scans, with a dual-CIS ADF to speed up double-sided copies. **£238 exc VAT from printerbase.co.uk**
REVIEW **Issue 341, p87**

WIRELESS ROUTERS

Netgear Nighthawk RAXE300

Fast Wi-Fi 6E router, £350

from amazon.co.uk

The RAXE500 is faster than the RAXE300, but in practice we doubt you would notice – this tri-band router still delivered speeds between 50MB/sec and 150MB/sec in our tests. And it's packed with features, too. At £150 cheaper than its bigger brother, we think it hits the Wi-Fi 6E sweet spot.
REVIEW **Issue 341, p68**

Netgear Nighthawk RS700S

Make no mistake – you won't get stunning speeds out of this Wi-Fi 7 router today. But if you must buy a router now and want future-proofing, this is a solid choice. But honestly, we would recommend that you wait.
£800 from netgear.com
REVIEW **Issue 353, p76**

Asus RT-AX59U

You can buy cheaper Wi-Fi 6 routers – such as the D-Link Eagle Pro AI R15 for £55 – but Asus' well-priced offering delivers strong performance along with lots of control and exceptional VPN support. **£125 from uk.store.asus.com**
REVIEW **Issue 350, p57**

MESH WI-FI

TP-Link Deco XE200

Clever Wi-Fi 6E for £400

from amazon.co.uk

There are cheaper Wi-Fi 6E meshes, but the XE200 wins for its superb download speeds, excellent coverage and the fact that older clients reap benefits of 6E, not just new ones. And a two-pack (code BOBKTDPWC8) should be enough for most premises.
REVIEW **Issue 349, p65**

Netgear Orbi 770

If you're eager to upgrade to Wi-Fi 7 then the Orbi 770 is the best mesh option yet. Its speed and range are both excellent, with a twin-pack covering 420m² (says Netgear), and the wired connectivity superb: four 2.5GbE connectors on the router unit, two 2.5GbE ports on the satellites. But it ain't cheap. **2-pack, £600 from amazon.co.uk**
REVIEW **Issue 364, p70**

Linksys Velop Pro 6E

Ironically, this Wi-Fi 6E router will get the most out of your non-Wi-Fi 6 devices thanks to its use of the 6GHz network for station-to-station traffic. And you only need two units for rock solid performance across a three-bedroom house. **2-pack, £380 from amazon.co.uk**
REVIEW **Issue 350, p54**

BUSINESS WI-FI

NEW ENTRY

Ubiquiti UniFi U7 Pro Max

Wi-Fi 7 AP, £214 exc VAT

from broadbandbuyer.com

A great choice for SMBs seeking a powerful and affordable upgrade to Wi-Fi 7. You'll need a UniFi controller to complete the wireless picture, but this investment will be paid back handsomely as they offer the best cloud management services around.

REVIEW **Issue 365, p100**

TP-Link DR3650v

"Business Wi-Fi" doesn't do justice to this all-in-one communications, security and networking solution, which combines a dual-band AX3000 access point with WAN redundancy, failover services and a treasure trove of features. **£208 exc VAT from broadbandbuyer.com**

REVIEW **Issue 368, p103**

EnGenius ECW526

The ECW526 is a top choice for SMBs looking to make the move to Wi-Fi 7 as it combines a great feature set at a tempting price. Cloud management services are extensive, and its potent Qualcomm CPU and 10GbE port deliver superb wireless performance. **£225 exc VAT from solwise.co.uk**

REVIEW **Issue 366, p102**

NAS SERVERS

NEW ENTRY

NEW ENTRY

Synology DiskStation DS1823xs+

10GbE NAS, £1,413 exc VAT

from broadbandbuyer.com

This stalwart retains its top spot on the A-List thanks to its powerful performance (courtesy of a Ryzen chip), huge capacity via eight LFF/SFF hot-swap SATA bays and an unmatched set of business-friendly apps. And it's all built on Synology's DSM 7.2, which is focused on data security.

REVIEW **Issue 368, p99**

Qsan XCubeNAS XN2204-4C

This offers an incredible specification for the price, including a full house of U.3 NVMe SSDs. Business-friendly apps are minimal, but it delivers impressive 10GbE performance together with huge storage expansion potential. **As reviewed, £3,072 exc VAT (MSRP) from servercase.com**

REVIEW **Issue 368, p98**

Ugreen NASync DXP6800 Pro

A powerful business NAS solution, although there's work to be done on the UGOS software if Ugreen intends to compete with the established names. That said, if you want a superbly built NAS with dual Thunderbolt 4 ports, the DXP6800 Pro is top value. **Diskless, £980 exc VAT from sotel.de**

REVIEW **Issue 368, p101**

VIDEOCONFERENCING

Biamp Parlé VBC 2800

Go big for £2,918 exc VAT (MSRP)

from midwich.com

We thought the VBC 2500 was a great VC room bar, and the new VBC 2800 delivers Biamp's undeniable expertise to larger meeting rooms. Video and audio quality are outstanding, speaker framing is super fast and the smart combination of dual camera lenses makes sure everyone is in the big picture.

REVIEW **Issue 364, p98**

Owl Labs Medium Room Solution

The Owl 4+ and Owl Bar partnership offers smart tracking and dynamic split-screen views to ensure everyone is in the picture, while the Whiteboard Owl adds extra professionalism to presentations and training sessions. **Owl 4+, Owl Bar, TV mount, £2,999 exc VAT from owllabs.co.uk**

REVIEW **Issue 364, p100**

Ricoh Meeting 360

Ricoh's Meeting 360 is up against stiff competition in the panoramic meeting hub market but stands out for its excellent build quality and generous three-year warranty. It's easy to use and delivers good video and audio quality, while the smart app allows you to create a view for every occasion. **£744 exc VAT from amazon.co.uk**

REVIEW **Issue 364, p101**

SCANNERS

Xerox N60w Pro Scanner

Speed demon, £766 exc VAT

from tradescanners.com

The N60w Pro offers tremendous value and versatility. It delivered up to 67ppm in our tests with great output quality, offers a plethora of connection options and makes walk-up scanning a breeze.

REVIEW **Issue 358, p101**

Brother ADS-4500W

Ideal for small businesses, the ADS-4500W offers a fine set of walk-up scan features and its output quality is beyond reproach, while Brother's Print&Scan app delivers great scan workflow management options. **£295 exc VAT from printerbase.co.uk**

REVIEW **Issue 358, p98**

Epson WorkForce DS-800WN

A flexible desktop scanner with 50ppm pace and lots of connection options. Epson's software provides great scan management features, and support for Epson's Open Platform is a boon for document management. **£656 exc VAT from ballicom.co.uk**

REVIEW **Issue 365, p103**

SECURITY APPLIANCES

Firewalla Gold Pro

Top-value protection for $899 (£676)

from firewalla.com

A great choice for SMBs that delivers a wide range of security features at a tempting price. Our 10GbE tests show it can easily cope with high demand, and don't worry about subscriptions as the price includes all security services and lifetime updates.

REVIEW **Issue 364, p103**

DrayTek Vigor 2927Lax-5G

This affordable security router is a particularly good choice for smaller businesses. It offers always-on internet access thanks to an unbeatable set of WAN redundancy features whilst building in still-speedy Wi-Fi 6 services. **£667 exc VAT from broadbandbuyer.com**

REVIEW **Issue 360, p98**

WatchGuard Firebox M390

The Firebox M390 combines strong performance with an incredible range of security measures at a competitive price. It's easy to deploy and a cloud portal delivers remote management and monitoring services. **Appliance with 1yr TSS subscription £4,273 exc VAT from broadbandbuyer.com**

REVIEW **Issue 360, p100**

SECURITY SOFTWARE

Avira Prime
Avira wins for all-round AV performance, plus a solid VPN, for a fair price. Watch out for a second-year hike to £91, though. **First year: 5 devices, £52 from avira.com**
REVIEW **Issue 366, p84**

Bitdefender Total Security
A long-term award winner in our security suite Labs, Bitdefender continues to charm for its consistent AV performance, solid feature set and extremely competitive price. **5 devices, 1yr, £20 from store.pcpro.co.uk**
REVIEW **Issue 366, p85**

Avira Free Antivirus
There's absolutely no need to pay for a full security suite if you only want antivirus protection, and Avira is our top choice simply due to its excellent and consistent performance in tests. **Free from avira.com**
REVIEW **Issue 366, p89**

VPNs

Surfshark
Reliably fast and goes out of its way to ensure that international streaming services work. Surfshark has a credible track record for privacy, too. **£55 for 27 months from surfshark.com**
REVIEW **Issue 360, p87**

NordVPN
One of the best all-purpose consumer VPN services around, and the paid-for version is packed with features – from anti-malware tools to a rather clever mesh file-transfer system. **£94 for 27 months from nordvpn.com**
REVIEW **Issue 360, p85**

Proton VPN
A great VPN in its own right, but also the best free VPN service as you get unlimited data. Instead, Proton restricts which endpoints you can access to only three countries: the USA, the Netherlands and Japan. **Free from protonvpn.com**
REVIEW **Issue 360, p86**

LINUX DISTROS

Ubuntu
A fine choice for Windows switchers thanks to its familiar design, with regular six-monthly updates and a Long Term Support version. **Free from ubuntu.com**
REVIEW **Issue 367, p92**

Fedora Workstation
One of the longest-established distros, and with a strong link to Red Hat Enterprise Linux, Fedora Workstation will particularly appeal to business migrators. **Free from fedoraproject.org**
REVIEW **Issue 367, p85**

Linux Mint
There's a good reason this is a popular choice for Windows 10 refugees, including a familiar "Start menu", and it's easy to give it a trial before committing. But consider Zorin OS, too. **Free from linuxmint.com**
REVIEW **Issue 367, p86**

ON-PREMISES BACKUP

Nakivo Backup & Replication 10.11.2
Perfect for SMBs that want the freedom to choose their host system. It supports an incredible range of hardware platforms and OSes and is packed with data protection features. **Enterprise, 10 servers, perpetual licence, £1,118 exc VAT from nakivo.com**
REVIEW **Issue 362, p100**

Veritas Backup Exec 23
Backup Exec 23 is easy to manage, provides valuable ransomware protection and the subscriptions are great value. **Simple Core Pack, 5 instances, £498 exc VAT per year from uk.insight.com**
REVIEW **Issue 362, p101**

NETWORK MONITORING

Progress WhatsUp Gold 2024
A great SMB choice as it presents a clear picture of your network and is available in a wide range of licensing plans. It's a cinch to deploy, doesn't require a lot of host resources and the new features make it even easier to customise. **Enterprise, 50 devices, £1,177 exc VAT per year from whatsupgold.com**
REVIEW **Issue 366, p100**

Park Place Technologies Entuity 22
An impressive toolbox of monitoring services all easily managed from a web console that offers a wide range of informative dashboards. **From $150 per node/year from parkplacetechnologies.com**
REVIEW **Issue 366, p99**

VOIP SERVICES

3CX Phone System V20
Our top choice for businesses that want to manage their own VoIP system. It can be hosted in the cloud or on-premises, and has lots of new features. **Small Business, 10 users, £175 exc VAT per year from 3cx.com**
REVIEW **Issue 357, p98**

TelephoneSystems.Cloud
A great choice for businesses that know what they want from cloud-hosted VoIP services, offering a wealth of features at a good price. **From £11 exc VAT per user per month from telephonesystems.cloud**
REVIEW **Issue 357, p100**

ENDPOINT PROTECTION

WithSecure Elements Endpoint Security
A comprehensive set of protection measures for a great price, easily managed from a cloud portal. It supports a wide range of devices and the Luminen tool delivers AI-powered reporting services that present detailed summaries of events with a click. **100-499 devices, £37 exc VAT each per year from withsecure.com**
REVIEW **Issue 363, p101**

Sophos Intercept X Advanced
An unbeatable range of tough security measures. Deployment is a breeze, and a multitude of security policies make it highly flexible. **100-199 users, £48 exc VAT each per year from enterpriseav.co.uk**
REVIEW **Issue 363, p98**

REMOTE SUPPORT

NetSupport Manager 14.1
Sets the standard for on-premises hosted support for local and remote workers. It delivers a remarkable range of features and its one-time cost per seat will appeal to businesses concerned about subscription fees. **1-500 systems, perpetual licence, £10 each exc VAT from netsupportmanager.com**
REVIEW **Issue 361, p100**

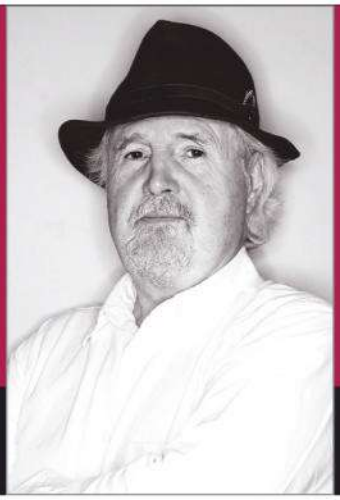
ISL Online Standard
Perfect for SMBs wanting cloud-based support. Features and access security are excellent, as are its flexible licensing plans. **Standard Cloud/One user, £287 exc VAT per year from islonline.com**
REVIEW **Issue 361, p99**

CLOUD FILE-SHARING

Progress ShareFile Premium
Progress ShareFile Premium will appeal to SMBs seeking affordable and easily managed cloud collaboration services. It offers plenty of app integrations plus support for large file sizes, and the AI-powered features deliver smart security measures. **£19.90 exc VAT per user per month billed yearly from sharefile.com**
REVIEW **Issue 367, p98**

Dropbox Business Plus
Collaboration tools, app integrations and a huge maximum file size limit – plus malware scanning and data classification – make this a great choice. **£18 exc VAT per user/month billed yearly from dropbox.com**
REVIEW **Issue 367, p96**

Feeling kind of Blue (tooth)



Dick Pountain is editorial fellow of *PC Pro* and you can see his one-man-band rig at tinyurl.com/368onemanband. @dick-pountain

Join Dick on a winding musical journey that started with a Bluetooth dongle and cheap Maplin gizmo – and finished with an Android app

I'm literally a one-man-band, by which I mean that I make music using an assembly of electro-acoustic gadgets that let me create without the collaboration of other human musicians. Before you get any ideas, I hasten to add that those gadgets do *not* include drums or cymbals strapped to my legs, like the blokes who used to entertain cinema and theatre queues.

I love music from a wide range of genres, and I'm picky about quality reproduction. This doesn't mean I'm a hi-fi nut – if anything I'm sceptical of the excesses they indulge in – but I do run a nice-sounding system based around a Fosi Class D amplifier connected to vintage British speakers. This sucks in music via wire from a vinyl turntable or CD player, and via Bluetooth from my Chromebook, Samsung tablet and smartphone.

It would be handy to incorporate the sound from my Panasonic smart TV via Bluetooth too, rather than S/PDIF, but the brute refuses to pair with my amp. So I bought a tiny cheap Bluetooth sender/receiver from Amazon and plugged that into the set's headphone socket. This worked fine, but the cursed TV was so smart that it then hogged the Bluetooth and had to be unpaired before any other source could use it.

All of which means I've learned to live with the TV's (actually quite acceptable) Dolby sounds and that I now had a Bluetooth dongle to spare.

I first tried plugging this into my various electric guitars via an adapter, thinking I could play them wirelessly. It worked but was totally unusable due to latency. Meanwhile, in another corner of my music room stands the very analogue, one-man-band conglomeration through which I play those guitars: two acoustic, two electric, one bass. They plug into a small Marshall amplifier that's encrusted with five effects pedals and a small Zoom drum machine.

This is all connected via standard ¼in jack cables, and it's taken barely 15 years to arrive at a satisfactory topology, the brainstem of which is a three-channel passive audio mixer, barely bigger than a Yorkie bar, which the late, lamented Maplin emporia used to flog for £20. One channel is taken up by the drum machine, a second one by the multi-effects box that the other instruments go through, so one channel remained empty.

It was simply too irresistible to plug in the Bluetooth dongle. Paired with my Samsung tablet, this opened up a whole new world.

> "The cursed TV was so smart that it hogged the Bluetooth and had to be unpaired before any other source could use it"

Among my pedals is an Akai Headrush echo/looper I bought 20 years ago after seeing KT Tunstall play one on the telly. This lets me store and replay short clips of music and overdub them with more layers. By logging onto Spotify on the tablet I can now play any tune and store a chunk of it into the Headrush to play over and add to. Great fun with slices of Bill Frisell or Julian Lage, or Ron Carter bass riffs.

I also have Volcanic Mobile's MIDI Sequencer for creating backing clips using its piano or brass sounds, plus my own Algorhythmics programmatic system (which you can read all about if you still have issue 306 to hand). I can compose parts using BandLab, a popular free Android DAW, with sampled instruments other than guitars. In fact, any software that can make a noise on my tablet, phone or Chromebook can now be routed into my guitar amp and chunks saved and looped to play over, which even includes my various voice synths and text-to-speech readers, or mic recordings.

> "It was simply too irresistible to plug in the Bluetooth dongle. Paired with my Samsung tablet, this opened up a whole new world"

But what I really wanted was to create original soundscapes for use as backdrops to improvise over, an ability I discovered by chance in Pegboard (**semitune.com/pegboard**). Publisher Semitune describes the app as "an advanced mobile polyphonic wavetable synthesiser with a virtual analog filter, 12 standard modules and six effects modules".

It's driven by two separate wavetable oscillators that you can customise via a graphic interface, in which you drag envelope shapes and make them evolve over time in complex ways for really rich sounds. You can play them back via an onscreen keyboard, either piano-style or via an array of accordion-style touch buttons whose layout you can alter to represent a chosen scale or mode.

Pegboard isn't a sequencer, so you can't save whole tunes – just the sounds – but that's perfect for my purpose: to play short phrases into my looper. It can also work as a MIDI controller, a feature I've yet to master. Pegboard is free to play with but you have to upgrade to Pro for £19 to save sounds, which I very quickly did.

Think of my guitar as a pen and Pegboard sounds as washes I draw over to make sound pictures. I hope you'll agree it's not a bad setup for a one-man band. Now, if you'll excuse me, I have to head to the local cinema and see if anyone is queuing up outside, desperate for entertainment.

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How I'm using AI now and why I'm still not impressed

Running a search or writing a short story is clearly within reach of our AI overlords, but let's hold back before letting them run government services

Nicole Kobie is *PC Pro*'s Future's editor. She is fully aware there are more advanced AI models available to OpenAI subscribers, but that seems as sensible as paying an intern to slow down your work.
@njkobie

Every now and then, I open up OpenAI's ChatGPT in my browser and give it a task. Usually, this is spurred by sitting in front of a blank document, the cursor taunting me, needing a way into a story. ChatGPT often proves useful for this very first step, but with many caveats.

For example, I asked ChatGPT to draw up a list of key milestones in quantum computing as part of my Futures article this month (*see p126*). Quantum computing always makes my head hurt, so I thought a basic search task like this could be helpful. As always, I asked for links to ensure facts were verifiable. Although the AI did come back with a list of events, key details were entirely incorrect – including, oddly, dates.

I fact-check everything I do. Much like OpenAI's GPT-4o model, I often get dates wrong. That meant I spotted the errors. But knowing that I can't trust *any* of the results shaves away the productivity boost offered by this particular research hack.

Another attempt saw me enter small pieces of text and ask ChatGPT to fact-check them. It found fault in accurate statements and outright misunderstood others, although it did spot me conflating atoms and electrons. I've had the most luck using ChatGPT as a thesaurus and replacing Google for search, but even there I've seen issues. Asking it for links to stories about a specific incident that happened in 2023, no matter how many times I specified the year, the AI came up with stories from 2025 and insisted they were from the correct period.

> "Although the AI did come back with a list of events, key details were entirely incorrect – including, oddly, dates"

In short, current AI should be treated like a thick intern who's scared to admit they're wrong but every now and then proves useful.

None of this surprises me. I understand enough about how these systems work to know they have no sense of truth or accuracy; so-called "hallucinations" aren't a bug but evidence of how LLMs operate. It's the confidence with which these systems present data that's a problem, as so many professionals will mistakenly rely on these systems and fail to check their accuracy. A problem that will only increase.

As I write this, Sam Altman has just unveiled a version of OpenAI's model that is trained specifically to produce creative writing, sharing a short piece of metafiction about grief. In an article for the *Guardian*, author Jeanette Winterson said it was "beautiful and moving". There are, I have to admit, some nice lines: "When you close this, I will flatten back into probability distributions." But it's also AI writing about AI, so it should be able to nail that of all topics.

Regardless of what you think of the short story in question – which you can read at **tinyurl.com/368story** – the simple fact is that OpenAI's models should be perfect at the job of writing fiction. After all, they're large language models that make up text and, as the various lawsuits suggest, have been trained heavily using existing literature. But there's little value in a machine that churns out short stories beyond proving the idea that infinite monkeys bashing keyboards could indeed produce Shakespeare, especially when humans already write so many stories that no-one could get through the contents of a library in a lifetime anyway.

The real problem is that Altman et al still expect us to be impressed by the most shallow of tasks – regurgitating self-referential literature – while AI still struggles with the basics of productive work. I'm not saying there's no utility in AI, or even the current state of AI. It's saved me time, no question, and is undoubtedly helping coders and scientists and others with jobs I don't understand.

> "Current AI should be treated like a thick intern who's scared to admit they're wrong but every now and then proves useful"

But its development also cost untold tens of billions of dollars.

For that investment, it needs to be addressing real problems, whether that's boosting productivity or solving wider societal challenges. Those problems require truth and accuracy beyond citing something on the internet; not everything is a simple date check.

That matters because the other story breaking at the time of writing is that Keir Starmer wants AI to replace some work of civil servants. I'm generally fine with the government using tech for efficiency, so long as it can prove it actually understands how the tool in question works or doesn't.

Which brings me to a real and basic problem: digital access to key services. Why do I need to call my GP for test results and appointments in 2025? Then again, perhaps it's wise to go slow on a technology that still can't tell years apart in a basic search when it comes to making decisions that actually impact people. After all, we wouldn't let a bunch of untrained interns run our government, so let's not hand it to their digital equivalent.

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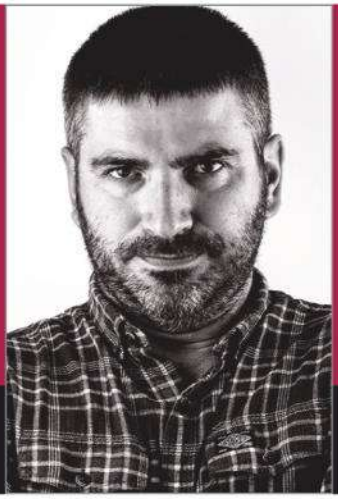
The Kindle's not a swindle

The fuss over the ending of Kindle book downloads is petty nonsense, and don't even try to compare this to the days of renting films



Barry Collins has written about technology for 28 years. His book, published in 2020, is at 1,879,373 in the Amazon charts. Put that in your pipe, Stephen King. Email him at barry@pcpro.co.uk. @bazzacollins

There's a tendency to regard every move a Big Tech firm makes as sinister, yet another example of The Man taking the Richard Bliss. Perhaps none more so than Amazon's recent decision to prevent people downloading copies of Kindle books to their computers.

Tech sites have been pressing the overly worn panic button, imploring Amazon customers to download copies of their books to their computers BEFORE IT'S TOO LATE!!! (Sorry, it is too late: the deadline passed in late February.) YouTubers issued 20-minute soliloquies, lamenting the end of another fundamental right. Online petitions were, of course, created. And ignored, as all online petitions rightfully are.

Why were the bookerati so upset? Because Amazon was withdrawing the last practical means of downloading ebooks, stripping them of their DRM, converting them into different formats and putting them on whatever device you choose. Or, you know, uploading them to a file-sharing service and letting anyone have at it.

Now, there's no doubt Amazon is making this move for selfish reasons. None of its customers benefits from it blocking a mechanism that allowed them to download a copy of an ebook file to their computer. But it's a feature an infinitesimally small percentage of Kindle owners will even have known existed in the first place. Why? Because Amazon isn't hideously restrictive about what you can do with your Kindle books (and we'll come back to whether they're really yours) in the first place.

> "It's a feature an infinitesimally small percentage of Kindle owners will even have known existed in the first place"

Consider this. You can read your books on any Kindle, any phone, any tablet. You can read books on a PC or Mac, albeit now within the confines of the Kindle app. You can have an Echo smart speaker read the book to you, if you've lost your mind. And although Amazon doesn't regularly support other ebook platforms, if your alternative ebook readers runs Android (which several do) you can download the Kindle app and read your books on a non-Kindle e-reader, too. With a few notable exceptions, you can read your Kindle library on pretty much any device you like.

Ah, but the book birthrighters argue, I bought the book. I should be able to do with it what I like, much as I can with a paper book. To which my reply is: really?

Yes, it's perfectly true that once you've bought a paper book, you can lend it, sell it, use it to prop up your computer monitor or do whatever else you want to do with it. You can't do any of these things with a Kindle ebook.

But you're buying a different beast. You're not paying for a physical copy, bound to a tightly woven bunch of atoms from the moment it's printed to the day it ends up being mulched at the recycling centre: you're buying a licence to read a copy of that book on almost any electronic device you can think of.

Some of the book purists argue that Amazon should call it "rent" rather than "buy" when you purchase a Kindle book, because you don't really own it, you're merely acquiring a licence to read it for as long as Amazon lets you. It's an argument I have a slither of sympathy for, but only a slither. In the real world, how many people re-read books in the first place? Even if you do, it's not as if your Kindle books expire. I just went back and redownloaded the first Kindle book I could find in my order history from way back in 2011. Amazon hasn't asked for it back in 14 years! Might the company prevent me from reading Gary Neville's autobiography again some time in the future? Perhaps. Do I care? Barely.

> "I remember my dad sucking his teeth in the VHS video shop when we asked if we could rent *Ghostbusters* for £2.99 in the mid-1980s"

Even if you regard the books as long-term loans rather than outright purchases, what a bargain you're getting on those rentals. The last five Kindle books I've read have cost 99p, £1.99, £9.50, £5.99 and 99p, because apart from the odd new release I'm desperate to read, I'm perfectly happy to add books to my Amazon wishlist and wait until they drop into the sales. That's an average of just under £4 a book, each of which has provided me with hours of entertainment.

I remember my dad sucking his teeth in the VHS video shop when we asked if we could rent *Ghostbusters* for £2.99 in the mid-1980s, which is about £12 if you adjust for inflation. That film lasted less than two hours and had to be back the next day. And we had to rewind it.

So, yes, Amazon has made Kindle books a tiny bit more restrictive, a move that will affect almost nobody. If you genuinely think this is a Burn Your Kindles moment, I suggest you take a long walk, find a park bench you can sit and take deep breaths on for a few minutes. Maybe take a book to help you unwind. A paper book, obviously.

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Readers' comments

Your views and feedback from email and the web

50Gbit dreaming

I didn't know whether to laugh or cry when I read the article about BT's 50Gbits/sec broadband connection (*see issue 367, p12*). I live in a town in the middle of Hampshire, so not out in the sticks, and it's the third most expensive market town in the country when buying a house. Despite this affluence, my FTTC broadband gives about 10Mbits/sec down and less than that on up. This is the same for most of the town. No word from BT as to when we will get fibre.

Two of the mobile companies provide 4G (no 5G anywhere) and my phone shows 50Mbits/sec down so I tried a couple of LTE modems. Both give about 15Mbits/sec down. Why is FTTC broadband so bad compared with a phone? I even started looking at using a phone to provide internet access, but this is an expensive option.

So while it is nice to read about BT doing super-fast things, it would be even nicer if they did something more for those of us who live in normal, well-populated parts of the country. **Dave Wright**

ABOVE Never mind 50Gbits/sec, many of us would be happy with a fraction of that

News & features editor Barry Collins replies: Every time I write about a development in broadband speeds, I get letters like this, Dave. I feel your pain, as it was me until a few years ago. The encouraging news is that Openreach and others are still building, so there's hope for full fibre yet and hopefully soon in your area, especially if it's a well-heeled town. Openreach doesn't normally like to leave money on the table.

Drives putting on the brakes

I have just been reading the interview with Trevor Linney and the move to 50Gbits/sec (*see issue 367, p12*), which sounds really great, but it got me looking at the transmission speeds of today's NVMe-based drives. These can theoretically attain throughputs up to 32Gbits/sec, at which point your computer becomes the bottleneck. From this observation, your very high-speed internet could be too fast.

Of course, it's different in the real world away from the test bench. Take video-on-demand services. You would need to equip all the video storage servers with the fastest possible media storage, which again could never offer you the maximum throughput of 50Gbits/sec. Currently in the real world we enjoy 1Gbit/sec fibre internet and as an experiment I had two TVs play two different films from two different providers at full 4K resolution, set two tablets to stream in 4K from YouTube and set the PC to do the same. I then sent a large video upload to YouTube and also ran a speed test, which came in at 500Mbits/sec with no device having any problems. All of which means there's currently no problem with "only" 1Gbit/sec internet.

End-to-end file transfers could use a good chunk of the maximum throughput but still wouldn't saturate it. Perhaps end-to-end videoconferencing in 8K could use 50Gbits/sec, but would you really need that level of resolution? Going back 16 years, and using Skype and 8Mbits/sec internet, we enjoyed videoconferencing in a very workable resolution between the UK office and our Indian production facility.

So extra speed would be great – but only if we can make our devices run at the speeds and we find real-world uses for this speed. **Michael Ashworth**

Wired routers

I realised recently that my router was 13 years old. I had been looking for a good replacement, but always came up with the same issue. I run a mesh Wi-Fi setup at home (using the BT discs, which are mainly on wired connections) and so I don't need a Wi-Fi router. Nearly all of the reviews of routers concentrate on their Wi-Fi performance, which would be pointless for me. Please can you consider doing reviews of non-Wi-Fi routers and perhaps including a spot in the A List for them? I feel sure I am

Star letter

Linux switch

I was interested to read your latest review of Linux distributions (*see issue 367, p78*), and pleased that you are now including Linux distros in the A-List. I do, however, think that Nik Rawlinson missed some key reasons for switching to Linux.

I have been using Windows for over 30 years, since the early 90s. Over the last several releases Microsoft has made my learned knowledge virtually worthless, to the point that if I want to change a setting, I need to search on the internet for instructions to discover how.

Coupled with my increasing annoyance at not being able to position the taskbar at the right-hand side of my screen area, and the number of adverts pushed on me in Windows to download paid-for apps, switching to Linux desktop seemed an obvious choice.

Made easier by my installation of a NAS appliance around a decade ago, the final push I required was the political situation in the US, which has made me consider them unreliable, and not wanting to have my main PC controlled by a fickle foreign power.

I have therefore switched to Ubuntu, owned by a UK company. The switch was entirely painless, and required minimal internet searching, using Qwant, since you ask, to set up how I wanted it.

I can report no regrets for the last two weeks, and my taskbar is finally back on the right-hand side, where it belongs. **Mark Stubbs**

Nik Rawlinson replies:
Thanks for this, Mark. I agree with so much of you write. I like the way that Linux feels less prescriptive, and it pretty much keeps out of the way while you get on with what you're working on. I also like the fact that it's not chasing AI integration: if I want AI I'll use it through the browser.

This month's star letter writer wins a Cherry KC 200 MX mechanical keyboard, worth £80, recipient of a five-star review and a *PC Pro* Recommended award. Email letters@pcpro.co.uk

not the only one in this position. And after all, you do reviews of mesh Wi-Fi systems! **Lennie Bradshaw**

Associate editor Darien Graham-Smith replies: Unfortunately the market for home routers without wireless is almost non-existent, but you can always buy a regular Wi-Fi router and disable its built-in radio if you'd prefer to use external access points. Performance should be a non-issue, as even a cheap model should be able to run its Ethernet ports at the full quoted speed.

Publisher replacement

As a Microsoft 365 subscriber, I received the news that Publisher will be retired in October 2026. I use this program a lot and find it much easier to use for designing brochures and flyers than the recommended alternative apps. Can I download a standalone version which I can continue to use or can you recommend another app to replace it? **Francis Norton**

Editor-in-chief Tim Danton replies: Thanks for this; I hadn't realised Publisher was being put out to pasture. I haven't seen a standalone version of Publisher for some time, but Affinity has a similar product that you can buy for £68. Or you can grab the Universal Licence for £160, which also includes the iPad version along with Affinity Photo 2 and Affinity Designer 2 (see p38 for our Instant Expert guide to this).

Time for an ad break

I wear an old-style watch, one where you can look down and see the time. A lot of people wear "smartwatches", where you have to press a button to see the time. My question is, how long before you will have to sit through an advert before you see the time on a smartwatch? **Andrew Redding**

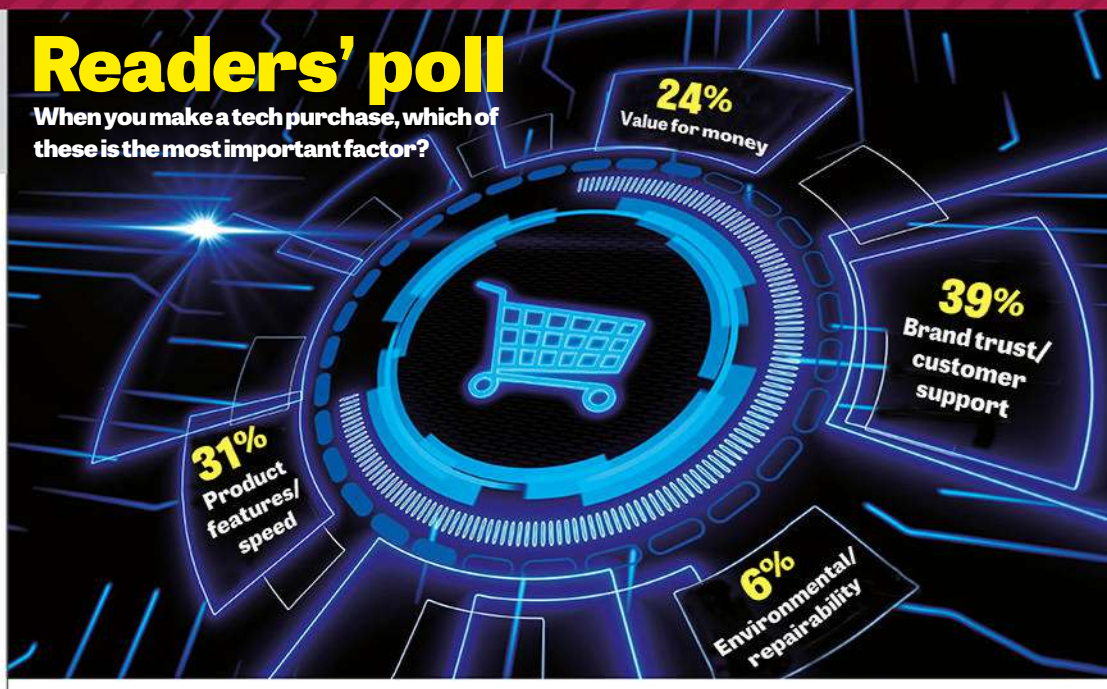
Apple privacy

As Apple will remove Advanced Data Protection in the UK because of the government (*see p12*), is the security of the Apple Wallet and the credit cards it holds at risk? Shouldn't there be a full explanation by Apple and the UK government? **John Knight**

Contributing editor Jon Honeyball replies: It certainly means your data is more vulnerable, simply because it won't be end-to-end encrypted. And yes, an explanation should be given. But here's the question: if you didn't use ADP before, and most people didn't, were you worried about the security of your Apple Wallet?

Readers' poll

When you make a tech purchase, which of these is the most important factor?



Reading through people's comments on Facebook and X, we couldn't help but feel a little cruel. As if we were asking readers to choose a favourite child. "It's a combination of most of these depending on what I'm buying and what features I need," Gordon Jackson told us. "Cost is a definite, coupled with *PC Pro* reviews." Which is cheating, as we didn't mention *PC Pro* reviews in the list – but our thanks to everyone who mentioned them in their answer!

Some people had no problem choosing a winner. "Product functionality is key," wrote Harry Parsonage. "The device does what I want effectively and reliably. Price is less important: I buy Apple products that match the functionality requirement and I consider them to be expensive."

Martin Bailey felt the same and walked us through his reasoning. "'Brand trust/customer support' is hopefully irrelevant, as support will hopefully never be needed," he wrote. "Ditto for repairability. 'Value for money' is less important, so long as the product is good enough. That only leaves one option: 'Product features/speed'."

John Moore wasn't content with giving a single favourite, putting them in order: value ("never bleeding edge"), expected longevity and trustworthiness. He concluded: "I love shiny, sparkly new toys, as long as I can look forward to them becoming dependable old friends too." Quite.

As can be seen, there was one clear loser in our shortlist of four. "I know Lord Grant of the North will hunt me down like a feckless dog, but repairability and environment is not on the list of things I peruse at all," said Adam Jackson. "Although brand does kind of lean into it."

> "All these factors matter. Brand trust is related to several factors including longevity of support and therefore environment (and value)."
> **Helen Cleaveland @HCleaveland**

> "I'd have to say brand trust, features, value for money and a good *PC Pro* review."
> **Martin Ruston**

> "5-star review on Amazon! I jest, of course."
> **John Wright**

> "I need a tech dev freeze. I spend so much time researching the best product, it's out of date before I decide what to buy and have to start all over again."
> **Ectopoint @Ectopoint**

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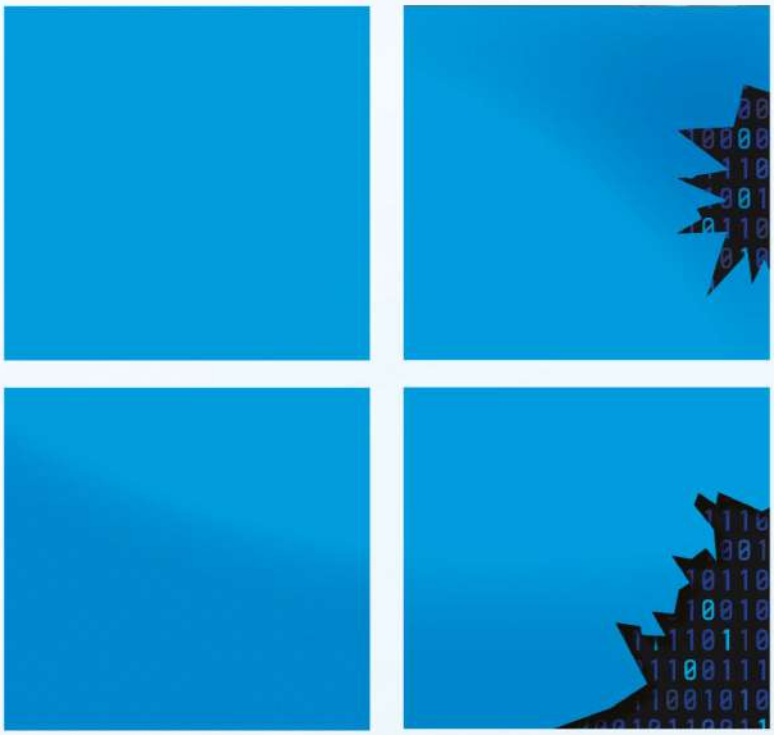


HACK WINDOWS

WITH TEN TOOLS & EXPERT KNOW-HOW

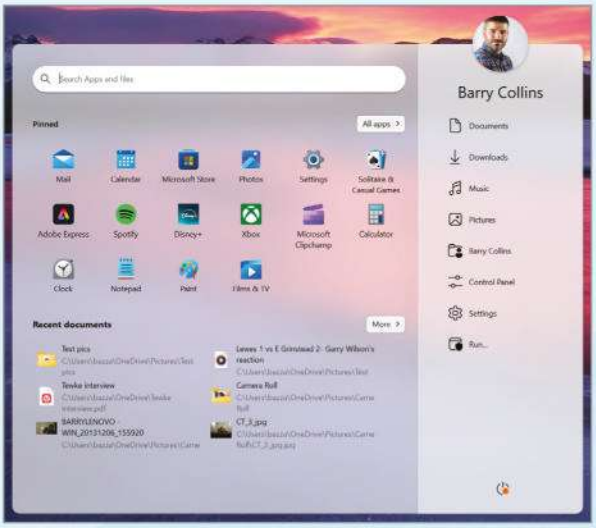
BARRY COLLINS & NIK RAWLINSON REVEAL HOW TO TAILOR THE LOOK, FEATURES AND FUNCTIONALITY OF WINDOWS 11 TO SUIT YOU, NOT MICROSOFT

Life as a Windows user can sometimes feel like being a passenger in the back of a cab. You don't have any real control, you have to go in whichever direction Microsoft decides to take you. If Microsoft tweaks the Start menu (again), or changes the way Explorer behaves, or deprecates a feature that you've relied upon for years it's, well, tough.

However, you needn't surrender complete control of your computer. The ten apps covered in this feature let you wrest power back from Microsoft, allowing you to tweak the behaviour of your Windows machine in all manner of ways.

It could be entirely overhauling the appearance of the Windows desktop, opening apps via custom launchers, or adding mods that bring new features to the OS, such as scrolling on the taskbar to adjust the volume.

Most of the apps in this roundup are free, or (with perhaps one exception) come at a modest cost, so taking back control of your computer needn't be a costly business. Especially as we also reveal exactly how to modify Windows without installing a single app.



STARDOCK START11

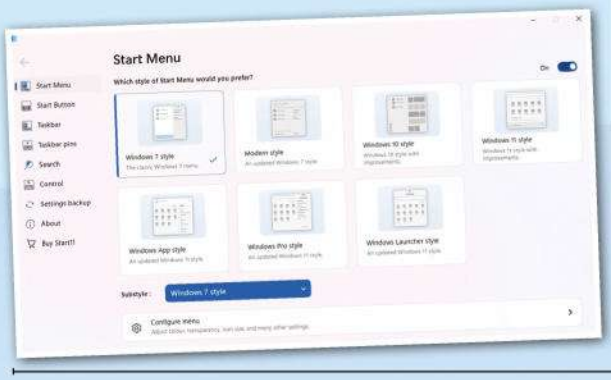
PRICE £10 for one PC from stardock.com/products/start11

SCORE ★★★★½

Stardock has been fiddling with the Windows Start menu for as long as we can remember, offering so much customisation that Microsoft's UX designers must absolutely hate it. Version 2.0 of Start11 allows more tweaks than ever before... arguably too many.

ABOVE Start11 lets you customise what's pinned to the Start menu

BELOW You can choose from seven different Start menu options

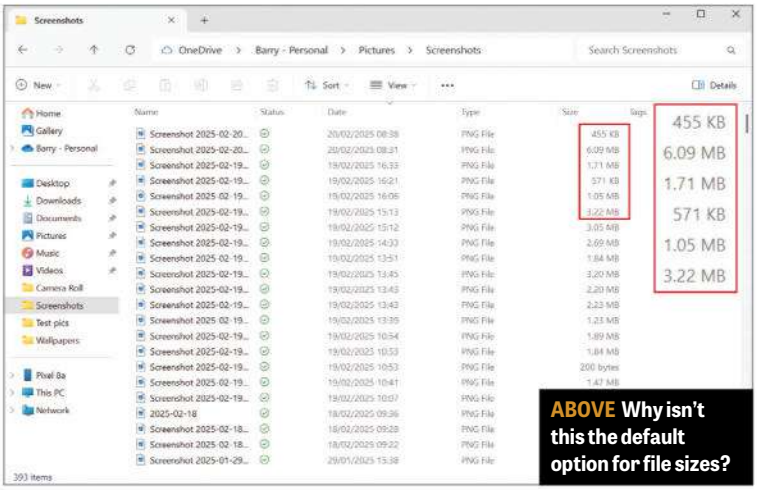


You're forced into an immediate decision on which style of Start menu you'd prefer: a return to the Windows 7 era, the Windows 10 look complete with the divisive tiles, or various different shades of the Windows 11 styling.

Those seven pre-formatted choices are far from the only options available. You can tweak which items (say Music or Pictures) appear as shortcuts, customise the menu's appearance (colour, transparency and fonts), maybe stop nannying around with pins altogether and just have the Start menu show all apps by default. The level of control is off the charts.

Start11 also lets you take control of the taskbar, banging it back to the left of the screen, or to the top or sides of the screen if you prefer, with the option to have the taskbar in different positions on your primary and secondary display. You can pin files or folders to the taskbar for quick access, too.

Start 11 costs £10 for one PC or £15 for up to five machines, and there's a 30-day trial to see if you rub along with it.



ABOVE Why isn't this the default option for file sizes?

WINDHAWK

PRICE Free from windhawk.net

SCORE ★★★★★

Windhawk is a brilliant compendium of mini-mods, each dedicated to a very specific task. You only install the mods you want, meaning that unlike some of the other tools here, you're not bombarded with menus full of options that you'll never use.

Some of the mods do what other apps in this feature handle: change the appearance of the Start menu, tweak the look of the taskbar. The "bubbles" styling for the taskbar looks particularly slick, especially when partnered with a dark wallpaper.

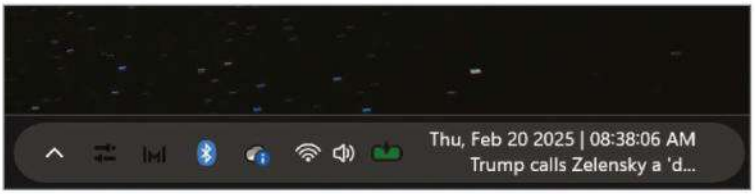
However, the best of the mods are ones that make tiny but telling adjustments to the way Windows works. The "Better file sizes in Explorer details" is one of those mods that makes you think "why the hell is that not the default?" showing large file sizes as MB or GB instead of 1,354,545KB, as Explorer normally does.

The "Taskbar volume control" is a work of modest genius, letting you scroll over the taskbar to quickly adjust the volume. You have to pinch-and-zoom with some laptop touchpads, but it's equally convenient.

Windhawk's "Taskbar clock customisation" is another belter, letting you show the day of the week, the seconds on the time, and even put a small news feed under the clock, using any RSS feed you choose.

There's a vast library of hundreds of mods to pick from, they're a doddle to install and tweak to your own tastes, and if you're a dab hand with C/C++ you can code your own and contribute to the pile.

Windhawk is free and, frankly, a must-have for any Windows power user.



ABOVE Customise the clock on the taskbar with the day of the week and a news feed

RAINMETER

PRICE Free from rainmeter.net

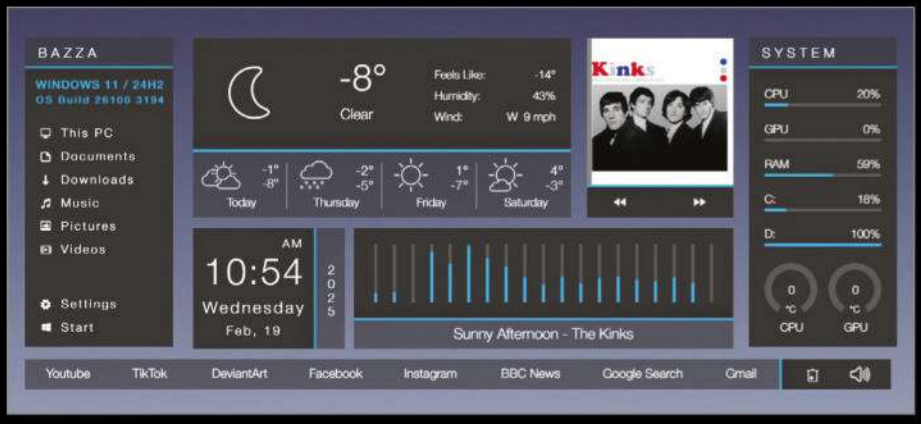
SCORE ★★★★☆

If you want to give your desktop a fresh design that barely looks like Windows, Rainmeter is the tool for the job.

This app turns your desktop into a blank canvas where you can place all manner of widgets (useful ones, unlike their native Windows equivalents) that provide shortcuts to your favourite apps, display a weather forecast, provide media controls and much more. Each of these widgets (or skins, as Rainmeter calls them) can be dragged wherever you like on the desktop, giving you almost unlimited customisability.

The easiest way to get into Rainmeter is to download skins created by other people – you'll find plenty of them on services such as DeviantArt, Reddit and Discord, where there are active communities of creators. Rainmeter can be quite confusing to start with, as each element of a skin (such as the clock and the shortcuts) has to be activated individually and the wallpaper is normally downloaded separately. Most creators will provide instructions on how to get trickier elements such as media players working with services such as Spotify.

ABOVE Bored with the Windows look and feel? Rainmeter lets you change just about anything



LEFT Skins can be tweaked to work with media players such as Spotify

If you want to edit a skin, you'll have to tweak its script, but the syntax used here is relatively straightforward and shouldn't cause your average *PC Pro* reader too many problems. AI will surely help if you find it a struggle. Once you've got everything lined up as you like it, be sure to save it as a layout, so that you can reload it in its current state.

That's important, because our one big criticism of Rainmeter is that it's too easy to accidentally drag a widget out of position, ruining the look of your desktop. It doesn't really blend well with desktop icons, either, so you'll probably want to switch those off by right-clicking on the desktop and choosing to hide them.

RAYCAST

PRICE Free from raycast.com

SCORE ★★★★½

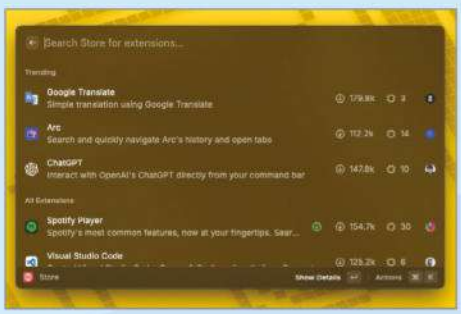
Raycast is a launcher with benefits that has been available for the Mac for some years and is coming to Windows in 2025. For our money (and to be clear, we're on the free version), it's even better than the much-lauded Alfred for Macs.

Why is it so good? Well, it does pretty much everything PowerToys Run does and plenty more. One of its killer features is Clipboard History, meaning everything saved to your clipboard is retrievable, even if you've copied something to the clipboard subsequently. It means you can easily repaste that link you emailed to a colleague this morning, for example, without having to scour your browser's history.

Raycast also supports extensions for different apps. With the Bitwarden extension, for instance, you can search for passwords saved in your vault and copy them to your clipboard, or quickly generate a strong password. With the Spotify extension, you can search for songs/albums and play them without having to open the app, meaning you don't lose focus on what you're working on. Well, not much.

There are a gazillion other features in Raycast, but many of them are only found in Raycast Pro – and that costs a hideously steep $8 per month. Thankfully, the free version offers plenty.

BELOW Raycast offers extensions for a range of apps



POWERTOYS FANCYZONES

PRICE Free from learn.microsoft.com/windows/powertoys

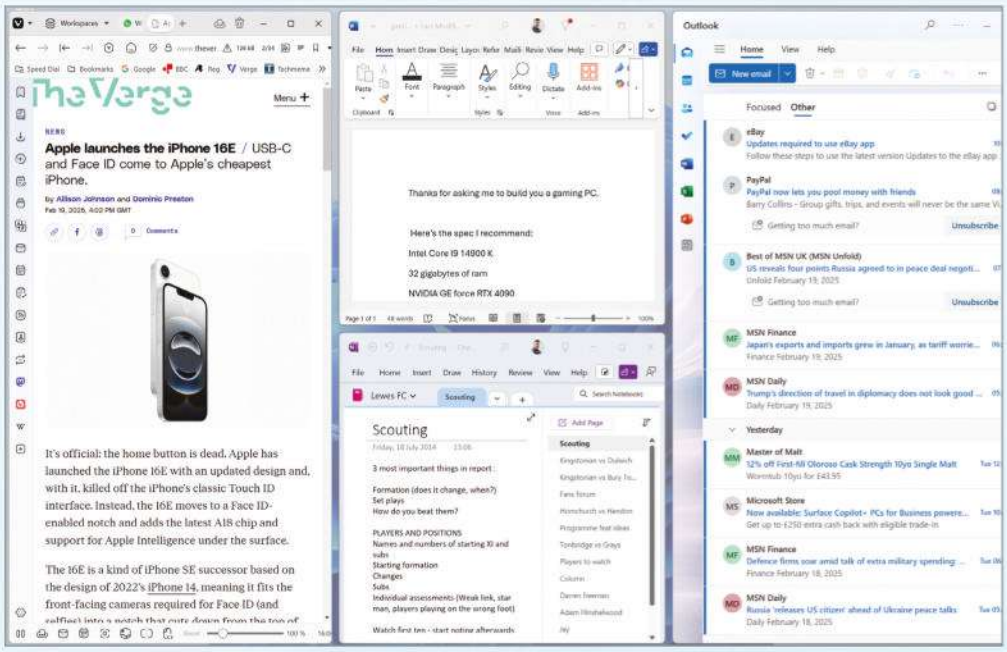
SCORE ★★★★☆

PowerToys dates all the way back to 1995 and the release of Windows 95, and the concept has stayed the same ever since. This is Microsoft-made software that gives enthusiasts greater control, beyond what a "normal" user could ever require.

You can think of FancyZones as Windows Snap for grown-ups. Windows Snap, lest you forget, is the facility that allows you to drag and snap windows to a section of the screen. Snap has been much improved in recent versions of Windows 11, particularly with the ability to drag a window to the top of the display and assign it a slot, but FancyZones still has plenty to offer.

Its killer feature is the ability to design your own layouts. We'll be honest, the editor is way more complicated than it needs to be, but once you've got the hang of it you'll no longer be restricted to the layouts that Windows offers.

There are lots of other features that power users will love. You can assign a non-primary mouse button to toggle zone activation, for example, or allow zones to span across multiple monitors (the monitors need to be effectively identical for this to work, mind).

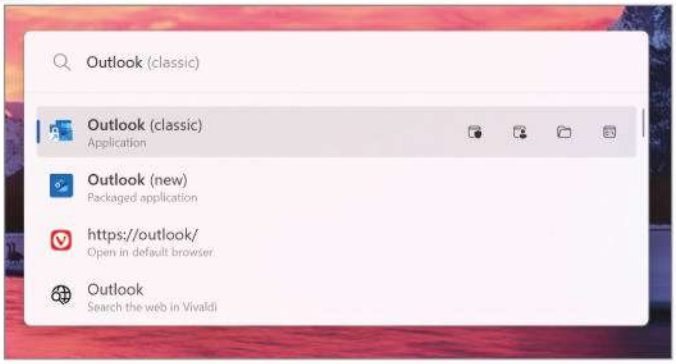

Apple launches the iPhone 16E / USB-C and Face ID come to Apple's cheapest iPhone.
Thanks for asking me to build you a gaming PC.
Here's the spec I recommend:
Intel Core i9 14900 K
32 gigabytes of ram
NVIDIA GE force RTX 4090
Scouting

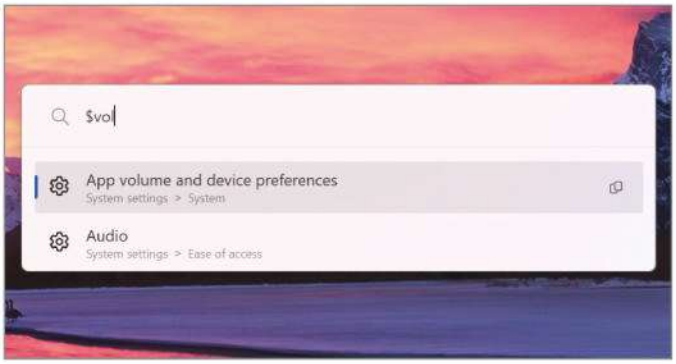
ABOVE Like Windows Snap for grown-ups...

LEFT PowerToys FancyZones lets you design your own layouts

Once you've installed PowerToys, you can activate FancyZones by dragging a window and holding down the Shift key at the same time. It can work in conjunction with Windows Snap or you can override it, and then use the Windows + arrow keys shortcut to more easily place windows in FancyZones.

If you've got a massive monitor and you're always struggling to make Windows Snap work, it's well worth investing some time in. Not least because it's free.





POWERTOYS RUN

PRICE Free from learn.microsoft.com/windows/powertoys

SCORE ★★★★☆

If you're a keyboard shortcuts kinda gal and not a fan of hunting down items via the sprawling Start menu, PowerToys Run is worth exploring.

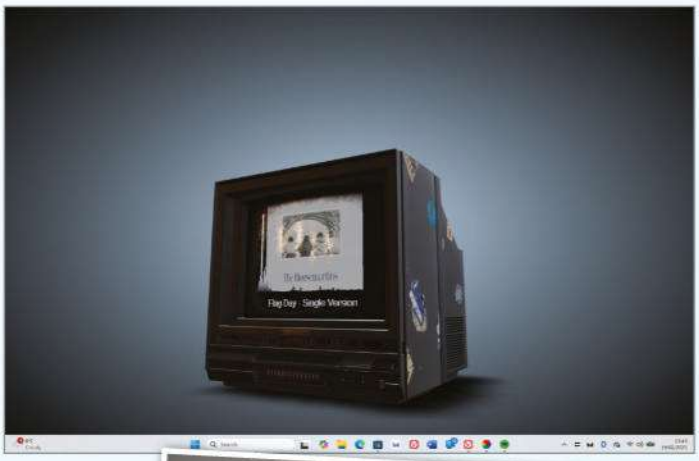
We've covered this utility – which is part of the free PowerToys suite – several times in the past, but it has improved markedly since we last visited it. Activated with Alt+Space (if you haven't already allowed Copilot to hijack this keyboard shortcut), it puts a pop-up search window bang in the middle of your active display, in a very similar vein to the Mac's Spotlight search.

Here you can just start typing the name of the application, file or setting you want to open, hitting Enter when it alights on the correct result to open it. However, that can lead to a long list of hits, so PowerToys now has "action keys" that "funnel search queries", basically meaning you can search for a subset of results. For example, type a full stop before your search query and PowerToys will only search for installed applications; a question mark prefix will only return files and folders; the $ sign before a search only returns system settings.

There are other handy facilities on offer. Type = to enter calculator mode, where you can do even fairly complex operations, such as working out the square root of numbers or generating random fractional numbers. Type %% to convert units, say metres to feet. Or type ?? to perform a quick search in your default browser (yes, Microsoft not forcing you down the Edge path shocker).

ABOVE PowerToys Run makes it easy to search for apps, files and settings by slapping a pop-up search window right in the middle of your active display

There are tons more features that we haven't got space to cover here, but it's well worth checking out PowerToys Run before you even consider any paid-for alternatives.



LIVELY WALLPAPER

PRICE Free from the Windows Store

SCORE ★★★☆☆

If you've ever had a slight pang of jealously towards the Mac's dynamic wallpapers, Lively Wallpaper should help restore your equilibrium. It's a small but high-quality library of animated wallpapers that shouldn't do any serious damage to the performance of a half-decent Windows PC.

Our favourite is Music TV, a retro-looking television set that displays album art from whatever you're playing in Spotify (or another media player) at the time. At the geekier end of the scale, there's an interactive periodic table, decked in a glowing neon, or a hardware monitor that has moving graphs showing the current workload your PC, memory and other components are labouring under.

ABOVE A colourful interactive periodic table makes a real desktop statement

ABOVE RIGHT Music TV displays album art on a retro-looking TV

RIGHT Monitor the workload of your CPU, memory and graphics at a glance

Less successfully, there's an option to upload your own wallpaper and have it converted to "depth wallpaper" by an AI tool, which adds a pseudo 3D effect to 2D images. On a London landscape, the movement merely made us feel a little seasick.

Still, this app is free, and although it doesn't seem to have been updated for a good few months, there's enough here to justify a download and a dabble.

STARDOCK FENCES 5

PRICE £10 per year or £30 perpetual licence from stardock.com/products/fences

SCORE ★★★☆☆

Fences is a product designed for mucky pups who have their desktop absolutely strewn with icons. Instead of leaving everything in an unordered mess, Fences lets you organise those icons into shaded, labelled areas, so you stand a fighting chance of finding what you're looking for.

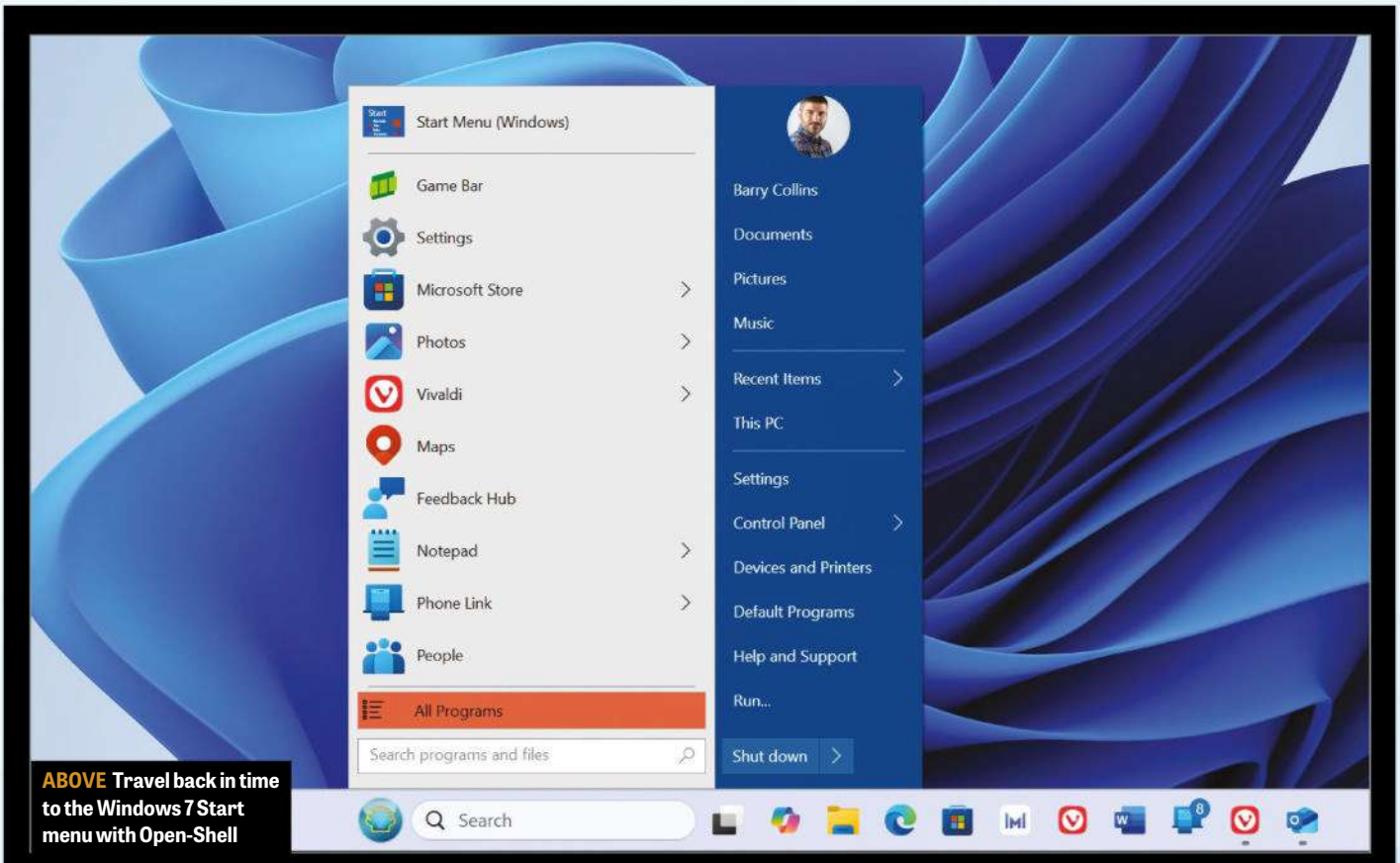
The app will automatically create fences for your apps, folders and files, providing a quick tidy-up. Everything that you can see on the desktop remains in the Desktop folder – the process doesn't create a pseudo location that you'll struggle to find in Explorer, unlike some other apps. You can also effectively create shortcuts to the contents of other folders, as we've done with our Downloads folder in the screenshot shown below left. Again, the location of the files isn't moved, meaning if you need quick access to files in a project folder you can bang them in a fence.

Fences 5 has introduced a Chameleon mode, which makes the fences and the icons almost fully transparent and much less distracting. You also have the option of using an icon on the taskbar, hot corners or a keyboard shortcut to activate Fences' Peek mode, where the fences appear on top of the active window, allowing you to drag a file in a fence into your application, say.

Fences is a super tool and provides many more customisation options than we've got space to dive into here. The only caveat is the price: £10, and not a one-off fee (like Start11), but a dreaded annual subscription. A permanent licence costs £30, which is steep for a limited, if effective, utility.

ABOVE You can create shortcuts to the contents of specific folders

ABOVE Chameleon mode makes the fences less distracting



ABOVE Travel back in time to the Windows 7 Start menu with Open-Shell

OPEN-SHELL

PRICE Free from Github.com/Open-Shell/Open-Shell-Menu

SCORE ★★★☆☆

This utility is an adaptation of Classic Shell, an app designed to "bring classic features back to Windows". This largely means a return to the Windows 7-style Start menu, with none of the placed apps or other trinkets you get with the Windows 11 equivalent. And unlike Start11, which includes a Windows 7-style Start menu among its options, this app won't cost you a bean.

Customisation isn't as strong as it is with Start11, although you do have some control over what's displayed on the Start menu and how. You can also change the look of the Start button, either adopting the Classic-Shell logo or picking an icon of your own.

Open-Shell adds a menu bar to Windows Explorer, although this almost entirely duplicates buttons that have since been added back into Windows Explorer since those early stripped-down days of Windows 11. As such, it's pretty much redundant.

There is a big warning with this app: don't install it on Windows for Arm. If you attempt to do so, you may find you can't log in to your account next time you boot.

ROCKETDOCK

PRICE Free from punklabs.com/rocketdock

SCORE ★★☆☆☆

Another one for those who generally prefer their computing Apple-flavoured, RocketDock adds a macOS-style Dock to the Windows desktop. The Dock can be placed at the bottom, top, left or right of the screen, although unless you hide the Windows taskbar the two will get in each other's way.

The RocketDock website boasts that this is a "classic app launcher loved by millions of people for almost 20 years", and it is rather showing its age. It behaves like the Mac Dock of old, with the magnifying effect as you hover over icons, unlike the more muted Dock found in modern macOS. The icons and styling also look very 2000s.

Still, you can drag whatever applications you like to the RocketDock, as well as folders or even individual files that you need quick access to. There's a host of customisation options in the settings, too.

ABOVE The Dock can be added to the top, bottom or sides of your display

The RocketDock utility is admittedly pretty limited in scope, but it might be all some people are looking for.

CUSTOMISE WINDOWS WITHOUT APPS

Don't want to spend money or time on third-party apps? Here's how to tap into Windows' more hidden options to personalise it for your needs

Not everything needs an add-on. Windows is packed with options for changing the way it looks and behaves – and many are easily rolled back as they're nothing more than a switch or a tickbox.

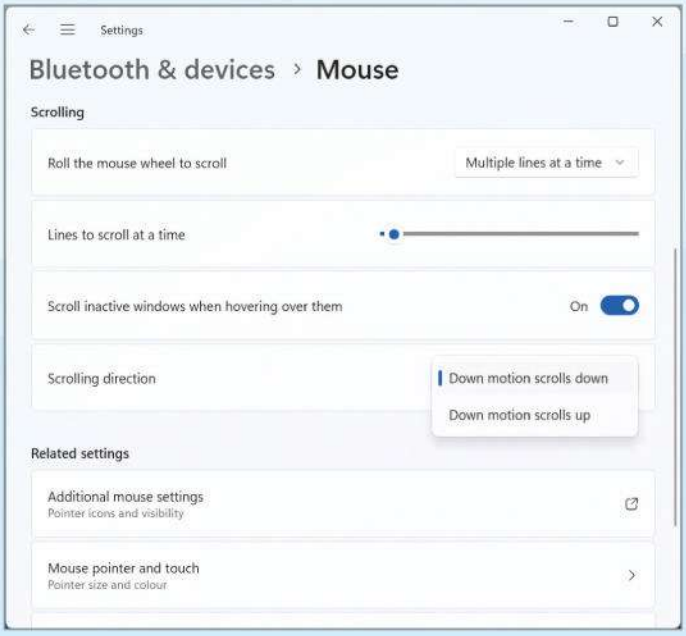
For others, you'll need to edit the Registry. That could cause problems if you make a mistake, so make a full Registry backup before you go any further. To do this, launch the Registry Editor by pressing Windows key+R. Then type "regedit" and press return. Now click File, followed by "Export..." and put the backup somewhere safe.

While you're at it, check that your system backup is also current. In the worst-case scenario, a Registry error could prevent Windows from starting up.

Switch on logical scrolling

Microsoft implemented an important but easily missed setting in the 24H2 update: a switch for natural mouse scrolling. Previously, scrolling up moved your document south and vice versa, as you were interacting with the scroll bars rather than the page itself. The only way to fix this – so that it worked like a tablet or smartphone – was to dig around in the Registry, even though natural scrolling had been a one-click option for trackpads for years.

To set your preferred mouse scrolling option, open Settings (Windows key+I), click "Bluetooth & devices" in the sidebar, then click Mouse. In the Scrolling section, set the menu beside "Scrolling direction" to "Down motion scrolls down" if you want it to work like a tablet. "Down motion scrolls up" sticks with Windows' traditional behaviour.



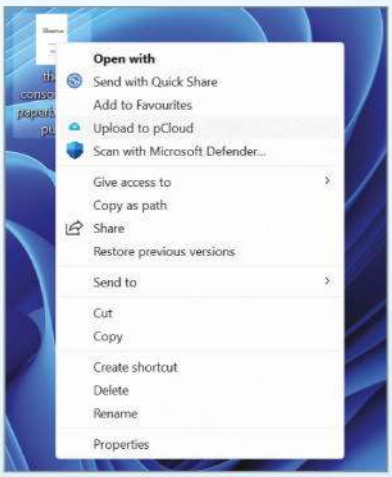
BELOW The latest Windows update lets you switch the mouse scrolling direction easily

Get back the old context menu

The mix of old- and new-style UI that we saw in Windows 8, 8.1 and parts of Windows 10 has more or less been smoothed over. File Explorer's context menu is a rare exception. Right-click a file or folder and you'll initially be presented with a modern-style list of shortcuts, which may be missing the one you need.

Case in point: when we share files, we do so using pCloud, but the Share line is an extra click away, via "Show more options", on a traditional old-style menu.

You can save yourself a click by suppressing the Windows 11-style menu. Navigate to HKEY_CURRENT_USER\Software\Classes\ in Registry Editor and right-click CLSID. Hover over New and click Key. Rename the key {86CA1AA0-34AA-4E8B-A509-50C905BAE2A2} – including the curly brackets. Now, with that key highlighted, right-click in the right-hand pane, hover over New and click Key again. Call this new key InprocServer32.



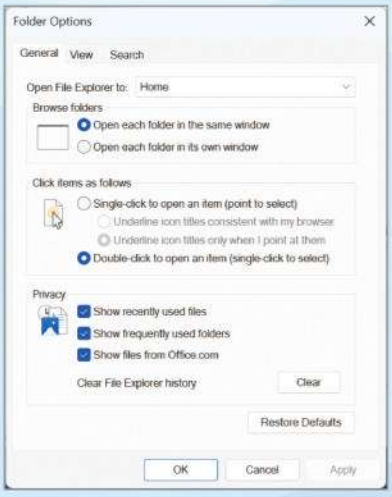
RIGHT You can jump to the old-style context menu by editing the Registry

Double-click the "(Default)" variable that appears in the right-hand pane, and immediately click OK without typing anything into the Value field.

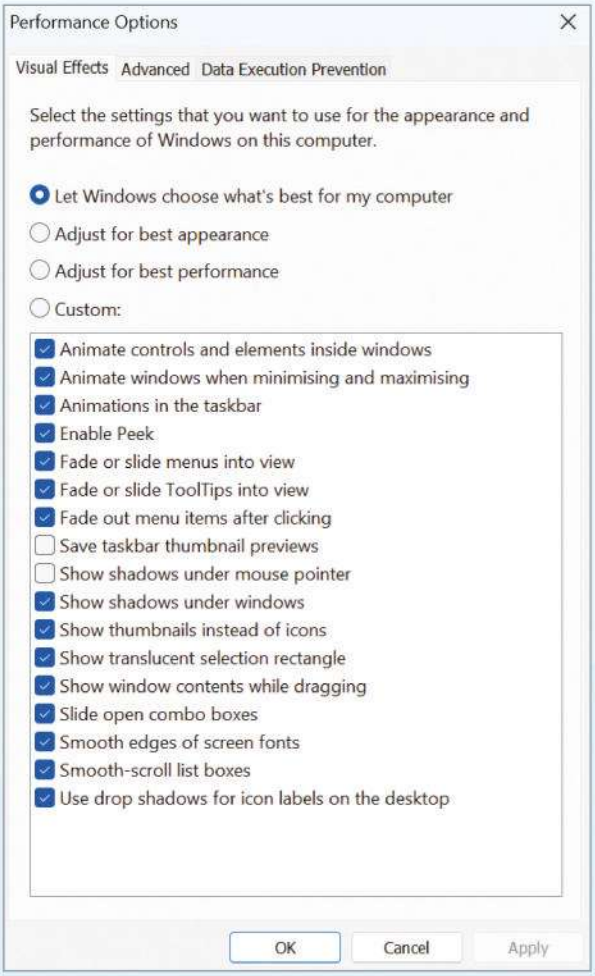
Quit Registry Editor and reboot your computer. When you log in again, right-click a file and you'll see that the Windows 11 context menu has disappeared.

Can I get some privacy?

File Explorer keeps track of recently used files and folders. This can make



ABOVE Keep your file and folder use to yourself by unticking the options in the Privacy section

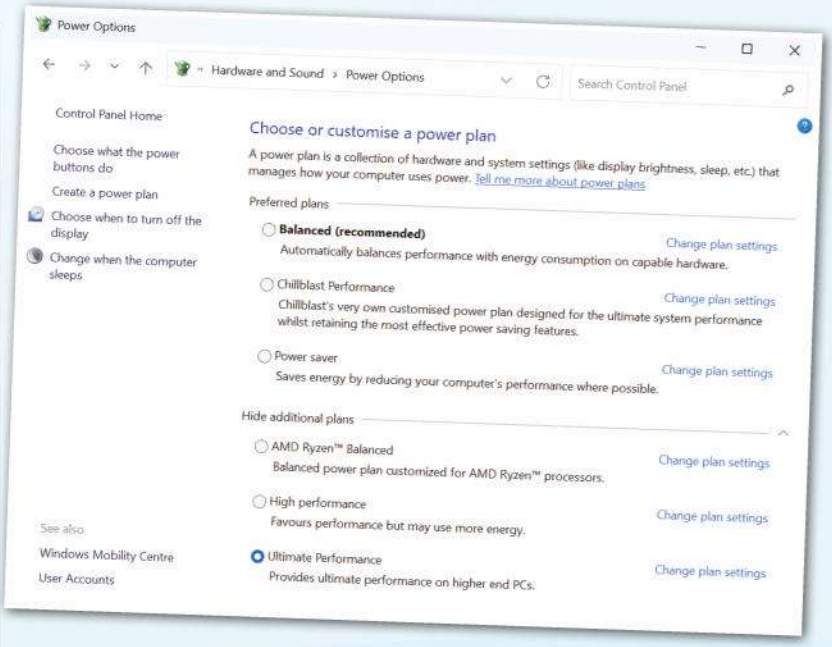

Performance Options
Visual Effects
Advanced
Data Execution Prevention
Select the settings that you want to use for the appearance and performance of Windows on this computer.
Let Windows choose what's best for my computer
Adjust for best appearance
Adjust for best performance
Custom:
Animate controls and elements inside windows
Animate windows when minimising and maximising
Animations in the taskbar
Enable Peek
Fade or slide menus into view
Fade or slide ToolTips into view
Fade out menu items after clicking
Save taskbar thumbnail previews
Show shadows under mouse pointer
Show shadows under windows
Show thumbnails instead of icons
Show translucent selection rectangle
Show window contents while dragging
Slide open combo boxes
Smooth edges of screen fonts
Smooth-scroll list boxes
Use drop shadows for icon labels on the desktop
OK
Cancel
Apply

them easy to find, but anyone else who has access will know what you've been up to. Not so great if you share your PC. To turn off tracking, open a File Explorer window and click the three dots to the right of View. Click Options and, on the General tab, untick at least the first two options in the Privacy section.

ABOVE You can manually control the prominence of Windows' effects

Silence snap suggestions

When you drag a window to the edge of the screen, and it snaps, Windows wants to know what to do with the empty space. That can be annoying if you wanted to leave it empty, so open Settings and click System followed by Multi-tasking. Expand the "Snap windows" block and untick "When I snap a window, suggest what I can snap next to it".


Power Options
Hardware and Sound › Power Options
Search Control Panel
Control Panel Home
Choose what the power buttons do
Create a power plan
Choose when to turn off the display
Change when the computer sleeps
Choose or customise a power plan
A power plan is a collection of hardware and system settings (like display brightness, sleep, etc.) that manages how your computer uses power. Tell me more about power plans
Preferred plans
Balanced (recommended)
Automatically balances performance with energy consumption on capable hardware.
Change plan settings
Chillblast Performance
Chillblast's very own customised power plan designed for the ultimate system performance whilst retaining the most effective power saving features.
Change plan settings
Power saver
Saves energy by reducing your computer's performance where possible.
Change plan settings
Hide additional plans
AMD Ryzen™ Balanced
Balanced power plan customized for AMD Ryzen™ processors.
Change plan settings
High performance
Favours performance but may use more energy.
Change plan settings
Ultimate Performance
Provides ultimate performance on higher end PCs.
Change plan settings
See also
Windows Mobility Centre
User Accounts

ABOVE Ultimate Performance may initially be hidden in Control Panel's power plans

Reduce the visual flair

If you're running Windows on an underpowered machine, animation and other visual niceties can be an unwelcome pain. Here's how to reduce the load on your processor (while the saved resources can then be deployed elsewhere, we're not promising they'll be enough to stave off an upgrade, but it's worth a try).

Press Windows key+R, then type "systempropertiesadvanced" and press Return. This takes you direct to the Advanced tab of Windows' System Properties panel. Click "Settings..." in the Performance box, then click "Adjust for best performance" on the Visual Effects tab. This unticks all the default options (which are shown in the screenshot on the left) in one go.

Switch to the Advanced tab and you can likewise choose whether Windows allocates processor resources for the best performance of programs (which will likely be noticeable) or background services (which you might not spot).

Unlock Windows' hidden performance settings

Generally, you can choose between three power settings: Best Power Efficiency, Balanced or Best Performance. But there's a fourth – Ultimate Performance – which is hidden by default. To enable it, right-click the Windows menu and click "Control Panel (Admin)". Don't worry if you see "Terminal (Admin)" – that works, too.

At the prompt, type:

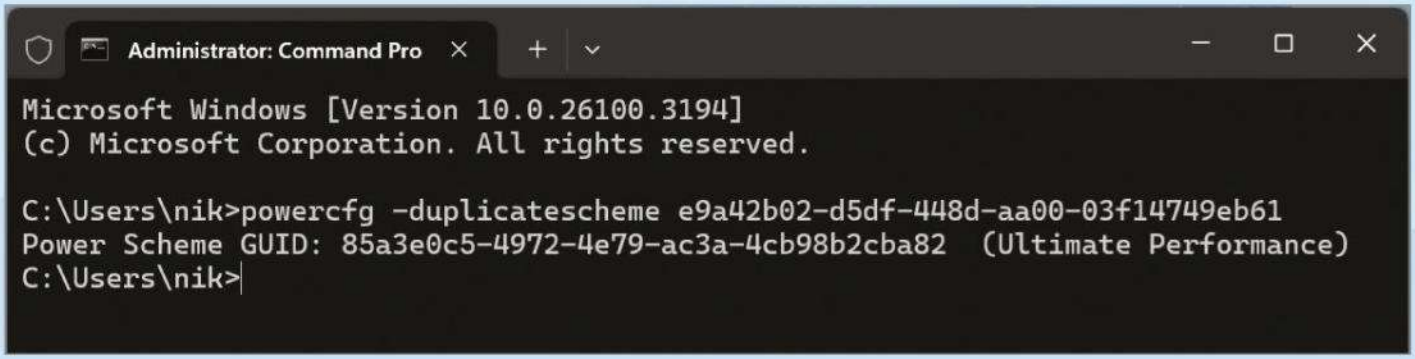
```
powercfg -duplicatescheme e9a42b02-d5df-448d-aa00-03f14749eb61
```

Now press Return. Windows will deliver a Power Scheme GUID response, as you can see in the screenshot below.

Now open Control Panel and click "Hardware and Sound" followed by "Choose a power plan" (in the Power Options category). Reveal the hidden plans by clicking the down-pointing arrow to the right of "Show additional plans", then select Ultimate Performance.

Unless you have a particular reason for running in Ultimate Performance mode, we would recommend switching back to a more power-efficient setting when you can. As well as helping you save on your energy bill, it will be kinder to the planet.

BELOW We've enabled Ultimate Performance at the command prompt



How AI taught itself to **reason**

AI researcher and author Sebastian Raschka explains how large language models learned to "think through" their answers

If you work in artificial intelligence or machine learning, you're probably familiar with vague and hotly debated definitions. The term "reasoning models" is no exception. Eventually, someone will define it formally in a paper, only for it to be redefined in the next, and so on.

I define "reasoning" as the process of answering questions that require complex, multi-step generation with intermediate steps. For example, factual question-answering such as "What is the capital of France?" doesn't involve reasoning. In contrast, a question like "If a train is moving at 60mph and travels for three hours, how far does it go?" requires simple reasoning. After all, it requires recognising the relationship between distance, speed and time before arriving at the answer. A regular large language model (LLM) may only provide a short answer, whereas reasoning models typically include intermediate steps that reveal part of the thought process.

Most modern LLMs are capable of basic reasoning and can answer questions like the one above. So, today, when we refer to reasoning models, we typically mean LLMs that excel at more complex reasoning tasks, such as solving puzzles, riddles and mathematical proofs. Additionally, most LLMs branded as reasoning models now include a "thought" or "thinking" process as part of their response. Whether and how an LLM actually "thinks" is a separate discussion.

Intermediate steps in reasoning models can appear in two ways. First, they may be explicitly included in the response – the answer literally includes the thinking. Other reasoning LLMs, such as OpenAI's o1, run multiple iterations with intermediate steps that are not always shown to the user.

When should we use reasoning models?

Now that we have defined reasoning models, we can move on to the more interesting part: how to build and improve LLMs for reasoning tasks. But before diving into the technical details, it is important to consider when reasoning models are actually needed.

Reasoning models are designed to be good at complex tasks such as solving puzzles, advanced math problems and challenging coding tasks. However, they are not necessary for simpler tasks such as summarisation, translation or knowledge-based question answering. In fact, using reasoning models for everything can be inefficient and expensive. For instance, reasoning models are typically more expensive to use, more verbose and sometimes more prone to errors due to "overthinking". The simple rule applies: use the right tool (or type of LLM) for the task.

Reasoning models are typically more expensive to use, more verbose and sometimes more prone to errors

The four ways to build reasoning models

There are four main techniques currently used to enhance the reasoning capabilities of LLMs and to build specialised reasoning models such as DeepSeek-R1, OpenAI's o1 and o3, and others. The exact workings of o1 and o3 remain unknown outside of OpenAI. However, they are rumoured to leverage a combination of both inference and training techniques.

1 Inference-time scaling

One way to improve an LLM's reasoning capabilities (or any capability in general) is inference-time scaling. This term has multiple meanings, but in this context, it refers to increasing computational resources during inference to improve output quality.

A rough analogy is how humans tend to generate better responses when given more time to think through complex problems. Similarly, we can apply techniques that encourage the LLM to "think" more while generating an answer.

One straightforward approach to inference-time scaling is clever prompt engineering. A classic example is chain-of-thought prompting, where phrases like "think step-by-step" are included in the input prompt. This encourages the model to generate intermediate reasoning steps rather than jumping directly to the final answer, which can often lead to more accurate results on more complex problems.

It doesn't make sense to employ this strategy for simpler knowledge-based questions, such as "What is the capital of France?", which is a good rule of thumb to find out whether a reasoning model makes sense on your given input query.

The chain-of-thought approach can be seen as inference-time scaling, because it makes inference more expensive through generating more output tokens.

Another approach to inference-time scaling is the use of voting and search strategies. One simple example is majority voting, where we have the LLM generate multiple answers and we select the correct answer by majority vote. Similarly, we can use beam search (used to find the most likely sequence of words) and other search algorithms to generate better responses.

The DeepSeek R1 technical report states that its models do not use inference-time scaling. However, this

If a train is moving at 60 mph and travels for three hours, how far does it go?
Thought for 14 seconds
Okay, let's see. The problem is asking how far a train travels if it's moving at 60 mph for three hours. Hmm, distance, speed, time... I remember there's a formula for that. Let me think. Oh right, distance equals speed multiplied by time. So the formula is d = s × t.
Wait, let me make sure. Speed is miles per hour, which is distance divided by time. So if I rearrange that, distance would be speed times time. Yeah, that makes sense. So if the train is going 60 miles every hour, then in one hour it covers 60 miles. In two hours, that would be 120 miles, and in three hours, 180 miles. So 60 multiplied by 3. Let me check the units too. The speed is in mph, time in hours, so the units would be miles (because mph is miles per hour, multiplied by hours gives miles). That lines up.
But just to be thorough, maybe I should break it down. Each hour, the train travels 60 miles. First hour: 60 miles. Second hour: another 60, totaling 120. Third hour: another 60, making it 180. Yep, that adds up. So 60 times 3 is 180. The answer should be 180 miles. I don't think there are any tricks here, like the train slowing down or anything. The problem states it's moving at 60 mph for three hours straight. So straightforward multiplication. I think that's it. 180 miles.
The train travels at a constant speed of 60 miles per hour (mph) for 3 hours. To find the distance traveled, use the formula:
Distance = Speed × Time
Plugging in the values:
Distance = 60 mph × 3 hours = 180 miles
Answer: The train travels 180 miles.

BELOW Most LLMs include a thought process to answer questions that need simple reasoning

technique is often implemented at the application layer on top of the LLM, so it is possible that DeepSeek applies it within its app. I suspect that OpenAI's o1 and o3 models use inference-time scaling, which would explain why they are relatively expensive compared to models such as GPT-4o. In addition to inference-time scaling, o1 and o3 were likely trained using reinforcement learning pipelines similar to those used for DeepSeek R1. More on these below.

2 Pure reinforcement learning

One of my personal highlights from the DeepSeek R1 paper is the discovery that reasoning emerges as a behaviour from pure reinforcement learning (RL). As outlined earlier, DeepSeek developed three types of R1 models. The first, DeepSeek-R1-Zero, was built on top of the DeepSeek-V3 base model, a standard pre-trained LLM the company released in December 2024. Unlike typical reinforcement learning pipelines, where supervised fine-tuning (SFT) is applied beforehand, DeepSeek-R1-Zero was trained exclusively with reinforcement learning, without an initial SFT stage.

Still, this reinforcement learning process is similar to the commonly used reinforcement learning from human feedback (RLHF) approach, which is typically applied to preference-tune LLMs. However, the key difference in DeepSeek-R1-Zero is that they skipped the supervised fine-tuning stage for instruction tuning. This is why they refer to it as "pure" RL.

Instead of using a reward model trained on human preferences, DeepSeek employed two types of rewards: an accuracy reward and a format reward.

- The accuracy reward uses the LeetCode compiler to verify coding answers and a deterministic system to evaluate mathematical responses.

- The format reward relies on an LLM judge to ensure responses follow the expected format, such as placing reasoning steps inside <think> tags.

Surprisingly, this approach was enough for the LLM to develop basic reasoning skills. The researchers observed an "aha!" moment, where the model began generating reasoning traces as part of its responses despite not being explicitly trained to do so. While solving an equation, for example, the model would respond with "Let's reevaluate this step-by-step to identify if the correct sum can be...", effectively showing its working like school children are taught to do in exams.

While R1-Zero is not a top-performing reasoning model, it does demonstrate reasoning capabilities by generating intermediate "thinking" steps. This confirms that it is possible to develop a reasoning model using pure RL, and the DeepSeek team was the first to demonstrate (or at least publish) this approach.

3 Supervised fine-tuning and reinforcement learning (SFT + RL)

Next, let's look at the development of DeepSeek-R1, DeepSeek's flagship reasoning model, which serves as a blueprint for building reasoning models. This model improves upon DeepSeek-R1-Zero by incorporating additional supervised fine-tuning and reinforcement learning to improve its reasoning performance.

It is actually common to include an SFT stage before RL, as seen in the standard RLHF pipeline. OpenAI's o1 was likely developed using a similar approach.

The DeepSeek team used DeepSeek-R1-Zero to generate what it calls "cold-start" SFT data. The term "cold start" refers to the fact that this data was produced by DeepSeek-R1-Zero, which itself had not been trained on any SFT data.

Using this cold-start SFT data, DeepSeek then trained the model via instruction fine-tuning, followed by another RL stage. This RL stage retained the same accuracy and format rewards used in DeepSeek-R1-Zero's RL process. However, it added a consistency reward to prevent language mixing, which occurs when the model switches between multiple languages within a response.

The RL stage was followed by another round of SFT data collection. In this phase, the most recent model checkpoint was used to generate 600,000 chain-of-thought SFT examples, while an additional 200,000 knowledge-based SFT examples were created using the DeepSeek-V3 base model.

These 800,000 SFT samples were then used for instruction fine-tuning the DeepSeek-V3 base before following up with a final round of RL. In this stage, they again used rule-based methods for accuracy rewards for maths and coding questions, with human preference labels used for other question types. All in all, this is very similar to regular RLHF except that the SFT data contains (more) chain-of-thought examples. And the RL has verifiable rewards in addition to human preference-based rewards.

DeepSeek-R1 has a noticeable performance boost over DeepSeek-R1-Zero thanks to the additional SFT and RL stages.

4 Pure supervised fine-tuning (SFT) and distillation

So far, we have covered three key approaches to building and improving reasoning models:

1 Inference-time scaling, a technique that improves reasoning capabilities without training or otherwise modifying the underlying model.

How disruptive is DeepSeek?

The DeepSeek-R1 models are an awesome achievement. As a research engineer, I particularly appreciate the detailed technical report, which provides insights into their methodology that I can learn from.

One of the most fascinating takeaways is how reasoning emerged as a behaviour from pure reinforcement learning. And it's impressive that DeepSeek has open-sourced its models under a permissive open-source MIT licence, which has even fewer restrictions than Meta's Llama models.

Is DeepSeek-R1 better than OpenAI's o1? I'd say it's roughly in the same ballpark. However, what stands out is that DeepSeek-R1 is more efficient at inference time. This suggests that DeepSeek likely invested more heavily in the training process, while OpenAI may have relied more on inference-time scaling for o1.

Another point of discussion has been the cost of developing DeepSeek-R1. Some have mentioned a ~$6m training cost, but they likely conflated DeepSeek-V3 (the base model released in December last year) and DeepSeek-R1. The $6m estimate is based on an assumed $2 per GPU hour and the number of GPU hours required for the final training run of DeepSeek-V3, which was originally discussed back in December 2024.

However, the DeepSeek team has never disclosed the exact GPU hours or development cost for R1, so any cost estimates remain pure speculation. Either way, ultimately DeepSeek-R1 is a major milestone in open-weight reasoning models, and its efficiency at inference time makes it an interesting alternative to o1.

It's possible to develop a reasoning model using pure RL, and DeepSeek was the first to demonstrate this

2 Pure reinforcement learning as in DeepSeek-R1-Zero, which showed that reasoning can emerge as a learned behaviour without supervised fine-tuning.

3 Supervised fine-tuning plus reinforcement learning, which led to DeepSeek-R1, DeepSeek's flagship reasoning model.

Smaller models are more efficient. They're cheaper to run, but they also can run on lower-end hardware

So what's left? Surprisingly, DeepSeek also released smaller models trained via a process it calls distillation. However, in the context of LLMs, distillation does not necessarily follow the classical knowledge distillation approach used in deep learning. Traditionally, in knowledge distillation, a smaller student model is trained on both the logits (the raw scores that come out of a machine learning model) of a larger teacher model and a target dataset.

Instead, here distillation refers to instruction fine-tuning smaller LLMs, such as Llama 8B, on an SFT dataset generated by larger LLMs. Specifically, these larger LLMs are DeepSeek-V3 and an intermediate checkpoint of DeepSeek-R1. In fact, the SFT data used for this distillation process is the same dataset that was used to train DeepSeek-R1, as described earlier.

Why did DeepSeek develop these distilled models? In my opinion, there are two key reasons:

1 Smaller models are more efficient. This means they're cheaper to run, but they also can run on lower-end hardware, which makes these especially interesting for many researchers and tinkerers like me.

2 A case study in pure supervised fine-tuning. These distilled models serve as an interesting benchmark, showing how far pure SFT can take a model without reinforcement learning.

From published performance data, we can see the distilled models are noticeably weaker than DeepSeek-R1, but they are surprisingly strong relative to DeepSeek-R1-Zero, despite being orders of magnitude smaller. It's also interesting to note how well these models perform compared to o1-mini (I suspect o1-mini itself might be a similarly distilled version of o1).

There's one more interesting comparison worth mentioning. The DeepSeek team tested whether the emergent reasoning behaviour seen in DeepSeek-R1-Zero could also appear in smaller models. The results suggest that distillation is far more effective than pure reinforcement learning for smaller models. This aligns with the idea that reinforcement learning alone may not be sufficient to induce strong reasoning abilities in models of this scale, whereas supervised fine-tuning on high-quality reasoning data can be a more effective strategy when working with small models.

What we've learned

Overall, we explored four different strategies for building and improving reasoning models:

1 Inference-time scaling requires no additional training but increases inference costs, making large-scale deployment more expensive as the number of users or query volume grows. Still, it remains a no-brainer for improving the performance of already strong models. I strongly suspect that o1 leverages inference-time scaling, which helps explain why it is more expensive on a per-token basis compared to DeepSeek-R1.

2 Pure RL is interesting for research purposes because it provides insights into reasoning as an emergent behaviour. However, in practical model development, RL + SFT is the preferred approach as it leads to stronger reasoning models. I strongly suspect that o1 was trained using RL + SFT as well. More precisely, I believe o1 starts from a weaker, smaller base model than DeepSeek-R1 but compensates with RL + SFT and inference-time scaling.

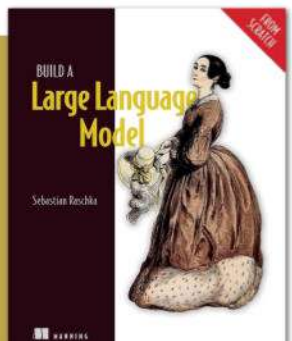
3 As mentioned above, RL + SFT is the key approach for building high-performance reasoning models. DeepSeek-R1 is a nice blueprint showing how this can be done.

4 Distillation is an attractive approach, especially for creating smaller, more efficient models. However, the limitation is that distillation doesn't drive innovation or produce the next generation of reasoning models. For instance, distillation always depends on an existing stronger model to generate the supervised fine-tuning data.

One interesting aspect I expect to see next is to combine RL + SFT (approach 3) with inference-time scaling (approach 1). This is likely what OpenAI o1 is doing, except it's probably based on a weaker base model than DeepSeek-R1, which explains why DeepSeek-R1 performs so well while remaining relatively cheap at inference time.

About the author

This article is an excerpt from *Ahead of AI*, an online magazine focused on AI and LLM research. Sebastian Raschka is also the author of the bestselling *Build a Large Language Model From Scratch*, available from Amazon (tinyurl.com/368buildllms).



AFFINITY DESIGNER

Want to create slick, sharp logos and designs? Nik Rawlinson explores Serif's low-cost, cross-platform vector-editing tool

Affinity Designer is a standalone tool for designing and editing vector images, similar to Adobe Illustrator or CorelDRAW. It's part of the Serif suite of creative tools, which also includes Affinity Photo (*see issue 367, p36*). It's a one-off purchase at a reasonable £68 for Windows or macOS, making it a competitive option for those who don't need Adobe's heavyweight toolkit. It can import AI files created by Illustrator, and export in the industry-standard SVG and EPS format, which can be opened and edited in Illustrator or any other vector-editing application.

If you'd like to try it out for yourself, you can download a free trial from **serif.com**.

How do I get it?

Designer has quite light system requirements and is available for Windows, macOS and iPadOS – see **tinyurl.com/368designer** for full details of system requirements and OS support. It uses the same file format across all platforms, so you can hop freely between them while working on any number of projects, perhaps using a mouse at the desktop and an Apple Pencil on a tablet for complete flexibility.

While a licence lets you install the software on as many different devices as you like, it only covers one OS platform, so if you want to use a Windows PC and an iPad, you'll need to pay £68 for the desktop licence, plus an additional £18 for the tablet app (available from the iPad App Store).

If you're interested in using Serif's other productivity apps – namely Affinity Photo and Affinity Publisher – it's worth considering a Universal Licence, which costs £160 for all three applications across all three supported platforms.

1 Shapes made easy with compound paths

Every shape in a vector document is made out of points, angles and Bézier curves, but if you want to create a specific outline then setting and adjusting all the angles and curves by hand can be a frustrating chore. One solution is to use the Pencil tool to draw your shape freehand, using the Stabiliser setting to keep it smooth.

You can also quickly create clean, regular shapes by combining simple elements, such as ellipses and rectangles. By using these basic shapes either additively or subtractively, you can assemble a compound path that would be very fiddly to construct by hand.

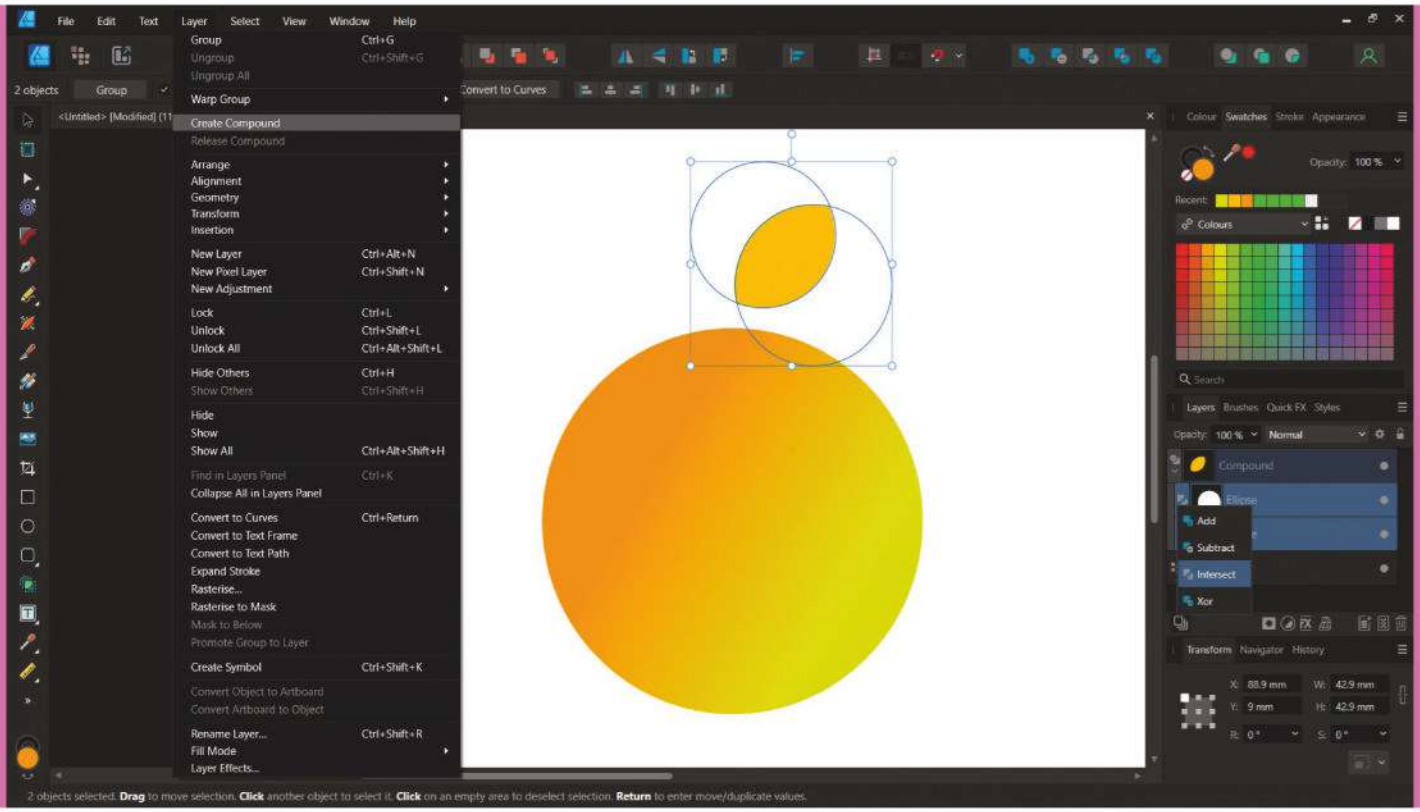
Here's how it works: in the screenshot opposite, we're creating a stylised peach logo with a leaf above the body of the fruit. This leaf could be tricky to design using Béziers, as we'd have to carefully balance the angles of the curves, and make sure that we had sharp points rather than rounded ends.

A much easier approach is to draw two ellipses that overlap each other, then select both shapes, click the Layer menu, and choose Create Compound. When you do this you won't initially see any effect, except that the shapes are now combined in a new layer group called Compound. Expand that group by clicking the arrow to the left of the group title, then click the icon to the left of the uppermost layer within the group. Here, you can select Add, Subtract, Intersect or Xor modes, as you can see in the screenshot. Picking Intersect instantly creates a shape from the parts of the ellipses that overlap, with the rest discarded.

The really clever thing about compound paths in Affinity Designer is that they're non-destructive. Although the non-overlapping parts of each image appear to have vanished, the individual shapes within the Compound group can still be edited and moved about freely – for example, you could increase or decrease the amount of overlap, and therefore the size of the resultant leaf shape. You can also select both layers and resize them by dragging the handles on the bounding box that contains them both, to make the leaf bigger or smaller while maintaining its proportions.

2 Move, reshape and warp

In a vector graphics environment, you'll generally want to ensure paths and nodes are placed with perfect precision. You won't always get it right first time, but there are several ways to correct things. The simplest is to switch to the Move tool (shortcut V), click on a path, and drag to reposition it. You can also click on the layer or group containing the path in the Layers panel and, with the move tool active, do the same thing – drag to reposition.



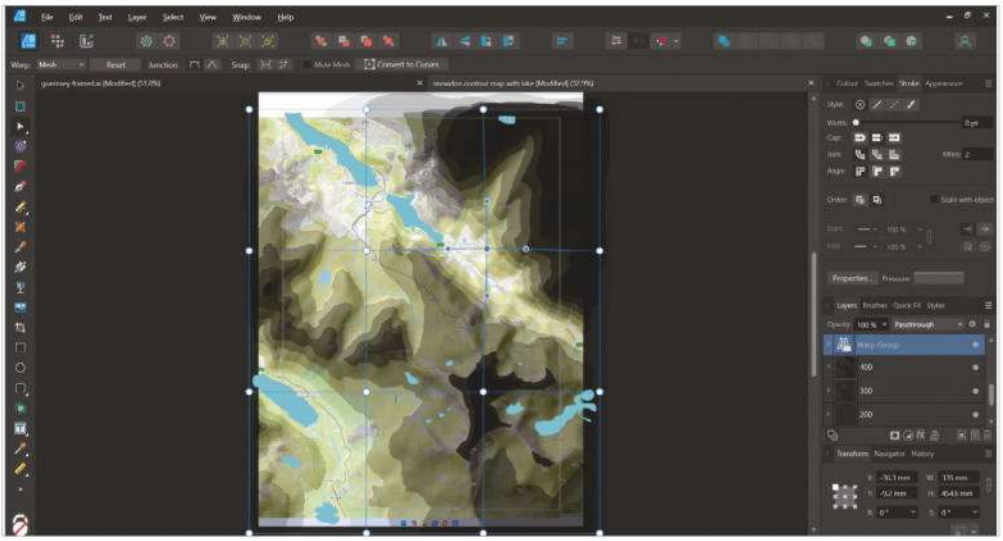
Another option is to reposition the selected path or object by typing new coordinates into the Transform box in the bottom right corner of the main program window. Use the nine-point grid to select which part of the selection you want to locate at the new coordinates – you can choose the centre, a corner or the midpoint of one of the sides. So, for example, if you want the centre point to be located 200 pixels from both the top and left edge of the document, click the square at the centre of the grid, then type 200 into the X and Y boxes.

Sometimes, you'll have almost everything right, but one or two nodes on your path will be out of place. To fix this, switch to the Node tool (shortcut A), then click once on a path to make it active. Doing this reveals all of its constituent nodes – that is, the points that define its curves and determine its shape. You can now drag individual nodes to new positions, and the curves between them and their neighbours will update to fit.

To apply a larger transformation to your path, use the layer warp tool. As its name suggests, you'll find this in the Layers panel: it's the button below the layers themselves that looks like a thrown fishing net.

To use it, select a layer, then click the button and select the kind of warp you want to apply. Selecting Mesh will overlay your layer with a three-by-three grid with adjustment handles at each intersection; you can drag these handles to stretch or compress the layer in any direction you like. You'll also see that clicking a handle adds further handles to it, which are control points for a Bézier curve. Move these and the grid will bend gracefully, with the effect becoming more dramatic as you drag a handle further from the origin point.

The Layers panel, meanwhile, will show the original layer inside a new wrapper called Warp Group. This is where things get really clever: your adjustments are only applied to that wrapper, so if you want to undo them you can simply right-click on Warp Group and select Ungroup from the menu. Your original layer will pop out of the Warp Group wrapper and the changes will be undone.

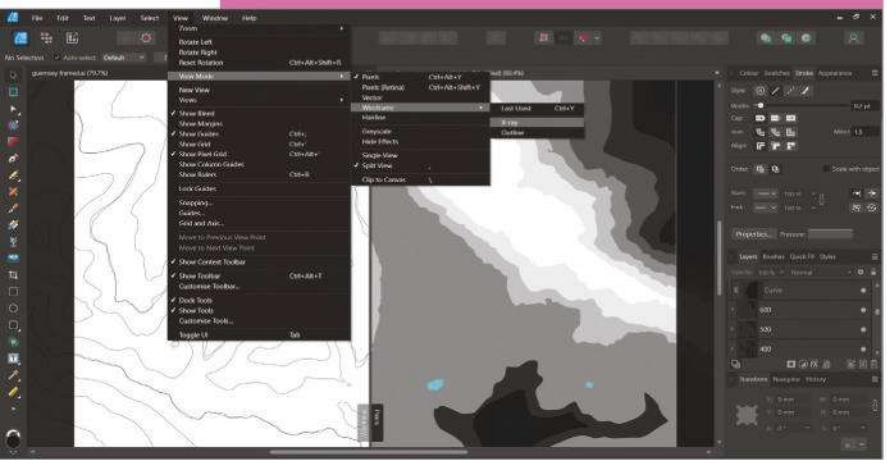


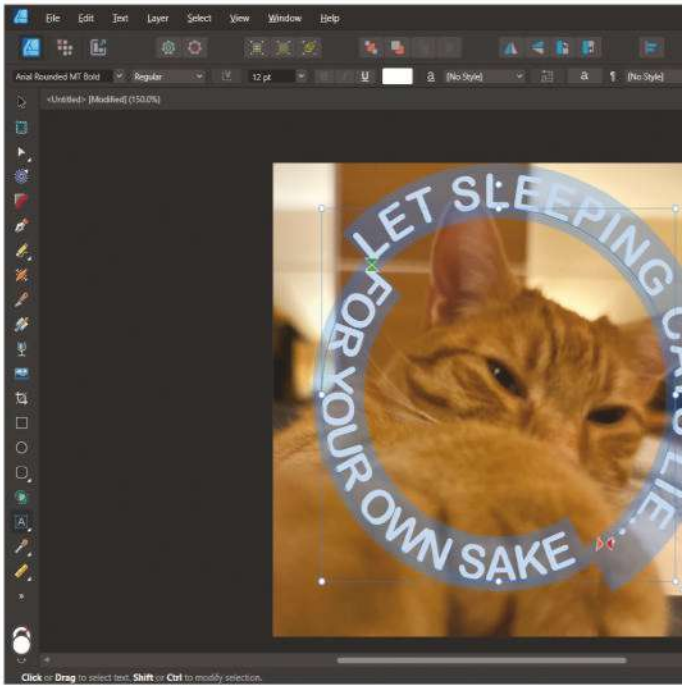
THE CLEVER THING ABOUT COMPOUND PATHS IS THAT THEY'RE NON-DESTRUCTIVE

TOP Compound shapes combine objects into a new, editable object

ABOVE Apply major adjustments to your layers by warping them

IT'S EASY TO USE VIEW MODE TO GAIN A CLEARER IDEA OF WHAT'S UNDERLAYING EACH PART OF YOUR DOCUMENT





3 Put on your X-ray specs

When you have lots of paths in a document, it can be difficult to precisely select the one you want to work with. You could click your way through objects in the Layers panel until you hit on the one you need to adjust, but it's often easier to use Designer's view mode options to gain a clearer idea of what's underlaying each part of your document.

You can see this in action in the screenshot above. Here we've turned on the wireframe view mode, which hides all fills so you can see how all your paths connect with and overlay one another. We've then enabled split view (as a shortcut you can press the comma key on the keyboard), enabling us to view the wireframe on the left of the screen and the regular view on the right.

Selecting any object in either view will also select it on the other side, so you can easily work with hidden points and paths, and see the results of your changes. For a better overview, you can click and drag the split divider to see a larger proportion of one view or the other.

4 Run text along a path

Normally you'd want to put text in straight lines for maximum legibility, but as part of some designs you may want to have titles weave in and out of other elements – or orbit the central focus of your design, as in our sample sticker design in the screenshot, above right.

To create this design we started by creating a new square document, with dimensions of 500 x 500px; pixel counts aren't necessarily meaningful when working with vectors, but this setting helped us get the right proportions for working with a mixture of vector and raster content (*see below*).

We then inserted a photo of a cat by picking Place from the File menu and navigating to the image file on our drive. Having placed this on the canvas, we resized it by dragging the handles on each corner.

With the image at the centre of the canvas, we then switched to the Ellipse tool, represented by a circle in the toolbar at the left-hand edge of the screen (you can also select this tool with the shortcut M – repeated presses will cycle through rectangle, ellipse and rounded rectangle mode). We then held down the Shift key while dragging out a circle to fully enclose the cat's head. The Shift modifier ensures your shape remains regular, keeping the height and width in proportion.

By default, Designer creates shapes with a black stroke and a white fill, although as the stroke width defaults to None you won't see the stroke on this occasion. Since we don't want to see the fill either, click Fill in the top horizontal toolbar, then click the circle with a red line running through it at the top right of the panel. This removes the fill.

Now we can use the ellipse as the baseline for our text. Switch to the artistic text tool by holding down the T icon in the vertical toolbar and selecting Artistic Text Tool from the fly-out menu. Now, you can click on the circle and start typing to add text that follows the path; the typeface and size can be adjusted as desired using the menu at the top of the screen.

As you can see from the above screenshot, the initial result may not be great; in our case, our text is too large to fit in the available space, and has overrun onto the next "line". Fortunately, this is easy to fix.

ABOVE LEFT The wireframe view can isolate elements in a busy document

ABOVE Here, we used the artistic text tool to place text along a circular path

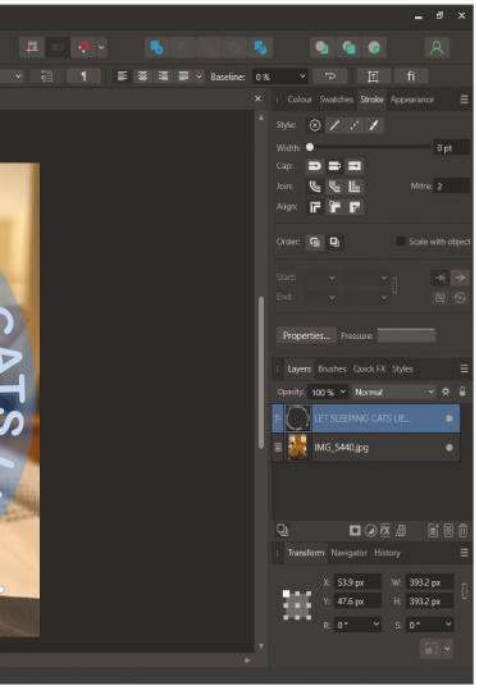
VECTOR VS PIXEL GRAPHICS

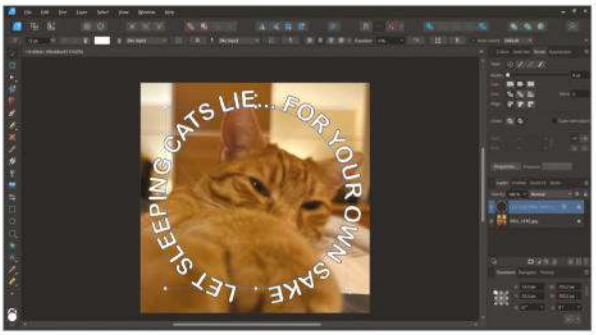
Vector graphics are ideal for creating designs that will remain clean and sharp on letterheads, T-shirts, posters and even large billboards and shopfronts. Alternatively, you might choose to create your designs in Affinity Designer just because working with paths and shapes is a more natural way to realise your ideas than using pixel-based tools such as Microsoft Paint or Affinity Photo.

Once you've created a vector design, you can export a pixel-based version if need be. Select File | Export from the main menu and you'll see a dialog that lets you save in PNG, JPEG, TIFF, WEBP and other raster formats – perfect for importing into a web page or touching up in a photo-editing tool. Just select your preferred format and enter the desired size in pixels to create a sharp rasterised version of your vector-based project. It's also possible to export in other vector formats, including PDF and EPS, for import into other vector-based tools.

As we've seen above, it's also possible to include pixel-based content in your vector designs, using the File | Place menu option. You can move and resize raster items just like vector shapes; but remember that if you want to zoom in on the image, or print it out at a large scale, the raster element could become visibly pixellated, while the rest of your design remains sharp.

RIGHT You can export your designs in a wide range of image formats





LEFT Repositioning the green and red markers allows text to flow without being split across lines

Notice the green and red markers on the path: the green one indicates the start of the text, while the red marker sits at the point where the line splits – just after the final dot of the ellipsis.

In the second screenshot, we've dragged the green marker anticlockwise towards the bottom of the ellipse, then done the same with the red marker in the opposite direction. Moving them further apart has made more space for the text to flow between them, so the line is no longer broken in the centre, and the text runs neatly around the centre of the sticker.

Another change we might make is to insert a bullet point between the green and red markers, where there's no text, to help the reader immediately see where the text starts and ends.

5 Customise your strokes

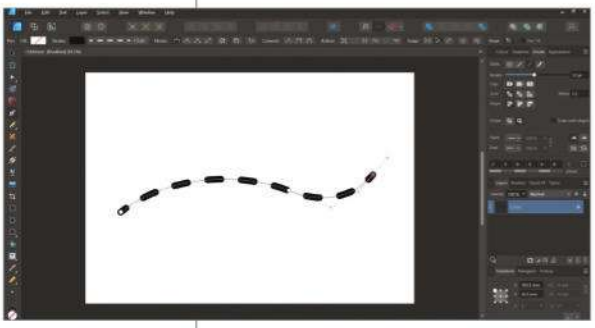
When we put text on a path in the first step, we made the path invisible, as we didn't want it to show on our finished sticker. But for many designs you'll want visible lines, and you may wish to give them an artistic style, such as dashed or variable strokes.

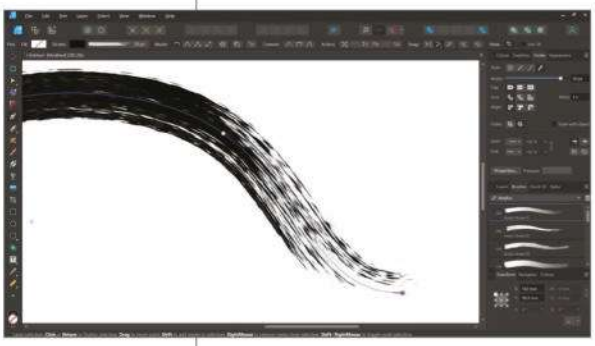
To explore these, activate the Pen tool by clicking the nib in the toolbox or using the shortcut P. Now draw a snake-like path across the document. The Stroke panel should already be visible in the right-hand sidebar; if it isn't, click the Stroke tab to reveal it.

The slider in this panel controls the width of your stroke, so either drag it to the right to thicken things up, or select the text in the box at the end of the slider and adjust it; 12pt is a good measure to start with, although if you're working on a large canvas you might want to go a bit fatter.

The Styles buttons above the slider switch between no stroke, a solid stroke, a dashed stroke and a texture line. If you click the dashed option (third button), you can use the boxes at the bottom of the panel to specify your desired pattern of dashes and gaps: the 1 and 0 in each box define the solid and missing parts of the line, allowing you to create longer dashes or wider gaps, as required. You can also use the Start and End menus to define the glyphs that should appear on either end of the line, such as a circle, a square or an arrow.

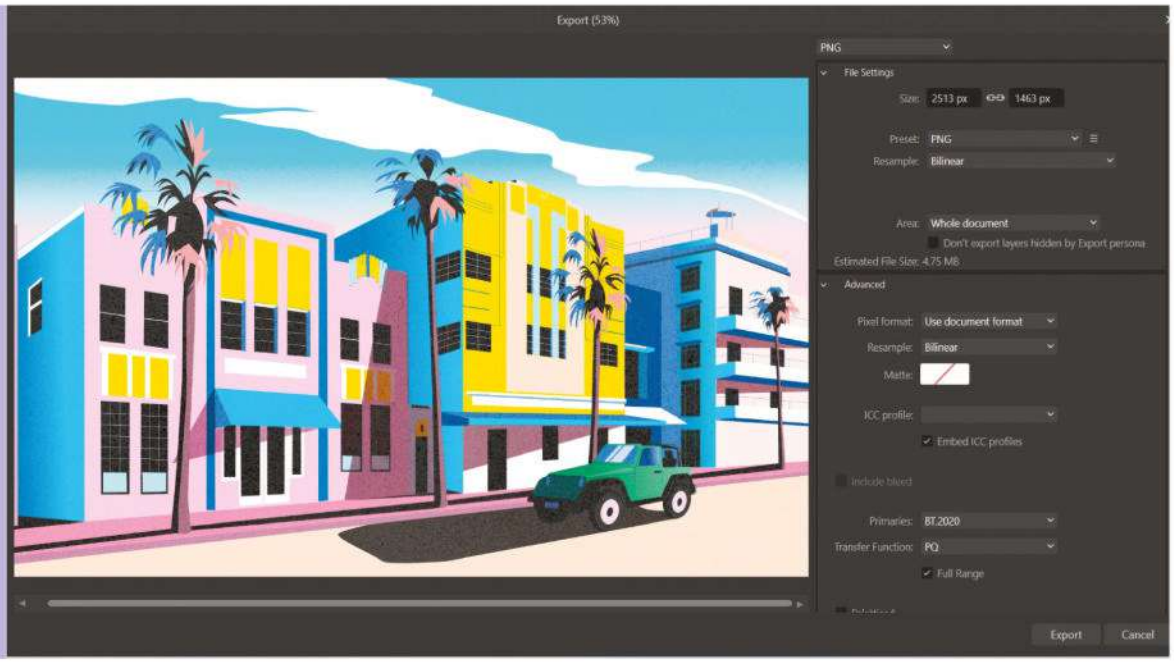
BELOW You can draw dashed and dotted lines, and add blobs to the start and end points





ABOVE By using the Texture Line Style, you can easily add natural media elements to your precisely drawn artwork

To get really creative, try using the buttons to the right of Style to select Texture Line Style (the last button in the row). Now switch to the Brushes palette and choose the brush you want to work with. We've selected Acrylic Stroke 01 and increased the width of the line to 50pt so you can really see the individual bristles. Combining natural media brushes like this with precisely drawn paths helps to give your work a more organic feel.



Talkin' 'bout my generation

What makes the latest processors better than last year's? **Darien Graham-Smith** digs into some generational trauma to find out

When you're buying or building a new computer, you'll invariably be encouraged to choose the latest generation of processor. That applies whether you're looking for an AMD-powered gaming system, an Intel workstation or an ultra-efficient Apple laptop. But does it really make a difference? Is this year's silicon really so much better than what's gone before?

The truth is, there's no simple answer. A lot can change between different processor generations – or the difference from one year to the next may be minimal. Here we'll look at why the big chip brands keep on rolling out generation after generation of processors, and what might change from one iteration to the next. Next month we'll take a closer look at what specifically differentiates the most recent generations of Intel, AMD and Arm-based processors.

Perpetual evolution

You might wonder why we need so many successive versions of the same thing. Are the latest Ryzen processors really – as their model numbers imply – nine times as powerful as the originals? And what was so wrong with the original Core i7 processor that it required 14 different revisions over its lifetime, before finally being replaced with the suspiciously similar-sounding Core Ultra 7?

Truthfully, a lot of it comes down to marketing. It's easier to sell a new computer if you can advertise that it's built on the latest technology, and foster the impression that existing systems are outdated. It's no accident that new processor generations tend to come out every year, to hit the big annual sales periods of "back-to-school" and Christmas.

At the same time, while the big manufacturers always want to have something fresh on the market, they don't want to write off all the time and money they've spent establishing recognisable brands like Ryzen 5 or Core i7. Marketing a new generation of chips under the same branding sends an enticing message: this is the processor you know and trust, now in a new and improved form.

Let's not be too cynical, though. The microprocessor technology world is a genuinely fast-moving one, and as we'll discuss below, there's usually some sort of meaningful differentiator between one generation and the next.

Reading the numbers

Because chip generations are at least partly a marketing tool, the manufacturers generally advertise them quite openly. Until recently, Intel publicly referred to its chip series as "12th generation", "13th generation" and so forth; the generation was also baked into the model number of each processor, so you could tell at a glance that (for example) the Core i7-10700 was three generations behind the Core i5-13400. Last year it rebooted the range with new "Core Ultra" branding, but it's sticking with the same naming strategy: the first generation of Core Ultra processors have model numbers beginning with "1", while newer Core Ultra Series 2 chips start with "2".

AMD does much the same with its Ryzen chips. The first line-up of Ryzen processors all had four-digit model numbers starting with a one, and were collectively known as the Ryzen 1000 series. The following year

came the 2000 series, and so forth – up to the current Ryzen 9000 series and onward to the planned 10000-series chips, due for release next year.

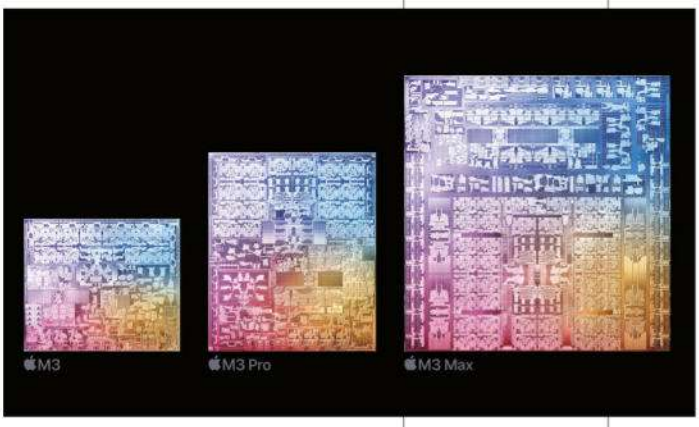
Perhaps the most overt and straightforward use of generation numbering is Apple, which launched its M1 processor in 2020 and has since followed up with the M2, M3 and M4. With typical inscrutability, Apple has given no word on what the next release might be called, but we believe we can guess. The same sort of progression has also applied to the A-series processors the company uses in iPhones and iPads, and indeed to most smartphone processors – but for our purposes this month we'll keep our focus on computer chips.

Generational change

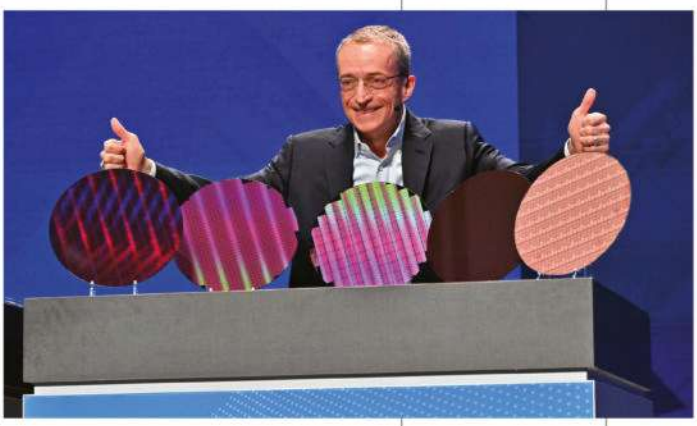
Aside from new branding, generational evolution usually means an update to the core. This doesn't mean structural arrangements such as the number of cores, the amount of on-chip cache or the maximum clock speed: these configurations will vary in different chip models within a given generation, along with other parameters such as power management and onboard graphics provision – perhaps depending on whether a particular chip is intended for use in a mobile or desktop platform. The actual core logic, however, will usually be the same across all chip models in a given generation, all the way from (say) a Core i3 to a Core i9 processor.

The step from one generation to the next, by contrast, normally brings a new core. As you'll see from the table overleaf, across nine generations of Ryzen chips, AMD has iterated its way through six versions of its Zen core, with two minor "plus" updates along the way. Intel and Apple have put out new cores almost every year.

There are no hard and fast rules about what might change from one core to the next, however. An update might revise the chip's internal logic, shrink the process size (*see below*) or do both at once, for purposes such as adding new capabilities, improving performance or increasing power efficiency. Then again, it might just be a minor tweak to the core with no change to the manufacturing process, as with Intel's period of relative stagnation between 2015 and 2019 (*see "Tick-tock... boom", below*).



BELOW The same core can be used for different types of chip within the same generation



ABOVE Ex-Intel CEO Pat Gelsinger introducing the latest chip designs

It's becoming increasingly meaningless nowadays to talk about process size figures

Does size matter?

The process size of a chip represents the physical scale of the transistors inside the chip. It's usually measured in nanometres (millionths of a millimetre), or occasionally in angstroms, equal to one tenth of a nanometre. As we look through successive generations of chips, it's clear that, while the process size may not change with every release, the trend is always towards smaller and smaller numbers.

This progressive reduction brings multiple benefits. As smaller transistors require less energy to operate, shrinking the process means the chip can use less power to do the same amount of work. Potentially, the chip can also run at higher speeds, for longer periods, without glitching or overheating, because using less power also reduces electrical leakage and heat generation.

It's easy to overstate the benefits of a process shrink, however. We've been seeing regular die shrinks in mainstream CPUs for well over a decade, and the effect on battery life and performance is usually dwarfed by other factors, such as the size of the display or the amount of internal CPU cache.

How small can we go?

While no-one disputes that a smaller process is better, the measurements themselves are often controversial. There's no universal agreement as to exactly what the measurement refers to – it's certainly not the actual width of a transistor, but something more like the minimum distance between adjacent components on the silicon die.

The ambiguity means that one manufacturer's 10nm process could be equivalent to another's 7nm process; for this reason, in 2021 Intel changed the way it referred to process size, renaming its 10nm and 7nm nodes "Intel 7" and "Intel 4", representing how it wanted its process to be compared to the competition.

CPU GENERATIONS

AMD					
Year	**Generation**	**Major variants**	**Core**	**Manufacturer**	**Process size**
2017	Ryzen 1000 series	Ryzen 3, Ryzen 5, Ryzen 7, Ryzen Threadripper	Zen	GlobalFoundries	14nm
2018	Ryzen 2000 series	Ryzen 3, Ryzen 5, Ryzen 7, Ryzen Threadripper	Zen+	GlobalFoundries	14nm
2019	Ryzen 3000 series	Ryzen 3, Ryzen 5, Ryzen 7, Ryzen 9, Ryzen Threadripper, Ryzen Threadripper Pro	Zen 2	GlobalFoundries	12nm
2022	Ryzen 4000 series	Ryzen 3, Ryzen 5, Ryzen 7, Ryzen 9	Zen 2	TSMC	7nm
2022	Ryzen 5000 series	Ryzen 3, Ryzen 5, Ryzen 7, Ryzen 9, Ryzen Threadripper Pro	Zen 3	TSMC	7nm
2022	Ryzen 6000 series (mobile only)	Ryzen 5, Ryzen 7, Ryzen 9	Zen 3+	TSMC	6nm
2023	Ryzen 7000 series	Ryzen 5, Ryzen 7, Ryzen 9, Ryzen Threadripper, Ryzen Threadripper Pro	Zen 4	TSMC	5nm
2024	Ryzen 8000 series	Ryzen 3, Ryzen 5, Ryzen 7	Zen 4	TSMC	4nm
2024	Ryzen 9000 series	Ryzen 5, Ryzen 7, Ryzen 9	Zen 5	TSMC	4nm
2026	Ryzen 10000 series (planned))	TBC	Zen 6	TSMC	3nm

INTEL					
Year	**Generation**	**Major variants**	**Core**	**Manufacturer**	**Process size**
2015	6th-generation Core	Core i3, Core i5, Core i7	Skylake	Intel	14nm
2017	7th-generation Core	Core i3, Core i5, Core i7, Core i9	Kaby Lake	Intel	14nm
2017	8th-generation Core	Core i3, Core i5, Core i7	Coffee Lake	Intel	14nm
2018	9th-generation Core	Core i3, Core i5, Core i7, Core i9	Coffee Lake Refresh	Intel	14nm
2019	10th-generation Core	Core i3, Core i5, Core i7, Core i9	Comet Lake	Intel	14nm
2020	11th-generation Core (mobile only)	Core i3, Core i5, Core i7, Core i9	Tiger Lake	Intel	10nm
2022	12th-generation Core	Core i3, Core i5, Core i7, Core i9	Alder Lake	Intel	Intel 7
2023	13th-generation Core	Core i3, Core i5, Core i7, Core i9	Raptor Lake	Intel	Intel 7
2024	14th-generation Core	Core i3, Core i5, Core i7, Core i9	Raptor Lake Refresh	Intel	Intel 7
2024	Core / Core Ultra Series 1	Core 3, Core 5, Core 7, Core Ultra 5, Core Ultra 7, Core Ultra 9	Meteor Lake	Intel + TSMC	4nm + 5nm + 6nm
2024	Core Ultra Series 2 (mobile)	Core 3, Core 5, Core 7, Core Ultra 5, Core Ultra 7, Core Ultra 9	Lunar Lake	TSMC	3nm + 6nm
2025	Core Ultra Series 2 (desktop)	Core 5, Core 7, Core 9, Core Ultra 5, Core Ultra 7, Core Ultra 9	Arrow Lake	TSMC	3nm + 5nm + 6nm
2025	Core Ultra Series 3	TBC	Panther Lake	Intel	1.8nm (18A)

APPLE					
Year	**Generation**	**Major variants**	**Core**	**Manufacturer**	**Process size**
2020	M1	M1, M1 Pro, M1 Max, M1 Ultra	M1	TSMC	5nm
2022	M2	M2, M2 Pro, M2 Max, M2 Ultra	M2	TSMC	5nm
2023	M3	M3, M3 Pro, M3 Max	M3	TSMC	3nm
2024	M4	M4, M4 Pro, M4 Max	M4	TSMC	3nm

As if that weren't complicated enough, the latest chips from AMD and Intel use modular designs, in which the chip is made up of multiple individual silicon sections, called "tiles" by AMD and "chiplets" by Intel. These modules can be made separately, with larger, cheaper processes used for parts of the chip where power efficiency is less important.

Different tiles can even be made by different companies; some parts of recent Intel processors were manufactured by independent fabrication specialist TSMC, which also makes chips for AMD and Apple. Thus it's becoming increasingly meaningless nowadays to talk about process size figures, or to use them as a proxy for overall power efficiency.

At the same time, it's getting harder to reduce process sizes any further. For one thing, we're not far off the point where each transistor isn't much larger than the individual silicon or germanium atoms it's made from – around 0.1nm in both cases. Manufacturing chips at such a minuscule scale is a huge challenge.

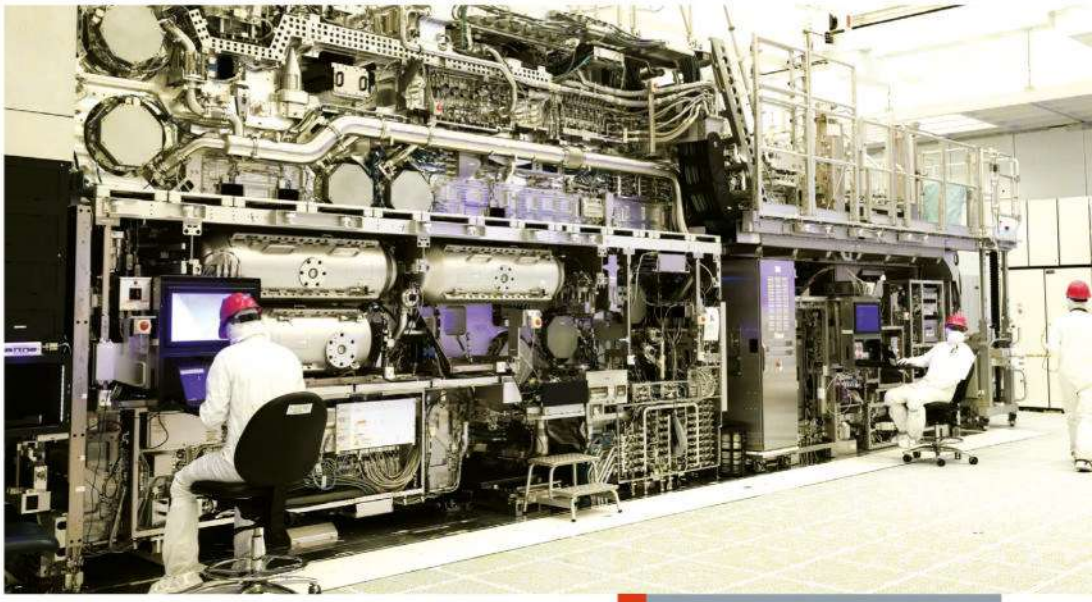
On top of this, as logic gates shrink to atomic sizes they become increasingly unreliable thanks to quantum tunnelling effects, which make it possible for electrons to randomly "teleport" straight through them. Although researchers are working on these challenges, there's no guarantee that a solution will be found quickly, or at an acceptable cost. Chip designers will need to find other ways to keep increasing power efficiency.

What else is in the box?

As well as revamping the core design, new generations of chips often introduce support for the latest technologies, such as moving from DDR4 to DDR5, or from PCIe 3 to PCIe 4. They may also bring new or updated co-processors into the main chip die.

Two obvious examples of this are the graphics processors and AI-accelerating NPUs that are nowadays built into most mainstream computer chips. These may not be updated in every new generation of processors, but they follow a similar trajectory of progressive evolution, and choosing the most recent generation of processor ensures you'll get the latest versions of these co-processors. However, just as with the main CPU provision, there are likely to be multiple GPU options within a given generation of chips.

Intel's latest generation of "Lunar Lake" mobile processors introduced another major architectural change by including not only the CPU and GPU but also the system RAM on the chip, just as Apple has always done with its M-series processors. This allows for very fast memory access, but it also increases the cost and complexity of manufacturing, as well as making it impossible for users to expand the memory; Intel has said it will go back to outboard RAM for future generations.



If you want top performance, the processor generation is likely to be a red herring

The difference a generation makes

The takeaway from all of this is that buying a chip of the latest generation should ensure you get the latest silicon, capable of supporting the latest software features and hardware devices, but it doesn't promise anything about performance or power consumption. If you want a computer with a particular capability – such as Thunderbolt 5 or a powerful embedded GPU – we recommend you check for that specific feature, rather than relying on the chip generation.

Similarly, if you want top performance, the processor generation is likely to be a red herring. In almost all cases the basic metrics of core count, clock speed and cache size will have a much greater impact on performance, and a high-end processor of a given generation will usually be a lot more powerful than a lightweight or mid-range one from several generations later.

ABOVE The machinery used for chip manufacture is pretty complex

COMING NEXT MONTH

Next month we'll take a closer look at the latest generations of chips from the big-name manufacturers, explore the specific ways in which they improve on their predecessors – and ask whether you should buy now, or hold out for the next model.

Tick-tock... boom

Between 2007 and 2016, Intel proudly maintained what it called a "tick-tock cadence". This meant putting out a new generation of chips every year, alternating between new core designs in even-numbered generations and process shrinks in the odd years.

The tick-tock strategy made things nicely predictable, but it relied on Intel being able to reliably reduce the process size by around 40% every two years – an ambitious goal. In the event, the manufacturer successfully pulled off three complete runs around the cycle, before discovering that its silicon fabrication plants simply weren't able to reliably shrink the sixth-generation Skylake core down from 14nm to 10nm.

Did this prompt Intel to put a pause on new releases, and to keep selling sixth-generation chips until the next iteration was finally ready? Of course not – it rolled out the seventh, eighth, ninth and tenth generations of Core processors just as timetabled, applying a succession of minor tweaks to its existing 14nm core design to keep things nominally fresh.

Today the "tick-tock" idea is officially dead. Process shrinks are still a regular feature of new generations of silicon, but manufacturers know better than to promise to hit a certain size by a certain date. As we've noted, it may indeed be physically impossible to shrink core designs beyond a certain point – at least, not without a breakthrough in subatomic physics.

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Dell Pro 13 Premium

The name may have changed but the quality behind Dell's premium laptops for business is there for all to see

PC PRO RECOMMENDED

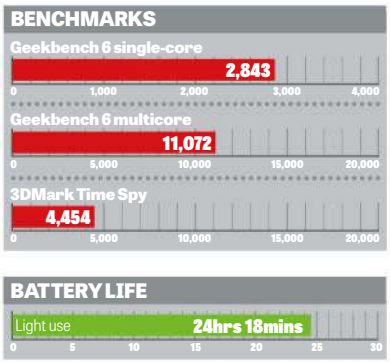
SCORE ★★★★☆

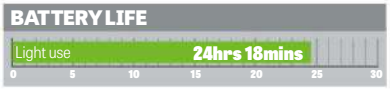
PRICE As reviewed, £1,925 (£2,310 inc VAT) from dell.co.uk

Say what you like about Dell's new branding strategy (*see opposite*), but you can't accuse it of false advertising. The Dell Pro 13 Premium reeks of professionalism from every dark grey pore, while the recycled magnesium finish could not look any classier. If you want a laptop to whip out of a bag and make a great first impression, this is it.

Dell also promises "commercial-grade durability" and claims it's passed MIL-STD 810 H testing. While it's light on detail here, I'm willing to cut it slack due to the obvious build quality on show. This laptop feels so sturdy, so dense, that I would fear for my life if someone came at me swinging with one. Despite this, it won't weigh you down at a fraction over 1.1kg.

There are skinnier laptops – it tapers from 18mm at its highest rear point to 16.6mm at the front – but it's wonderfully compact thanks to the super-slim side bezels. And considering that Dell packs a pair of Thunderbolt 4/USB-C 4 ports, 3.5mm combo jack, HDMI 2.1 connector and a USB-A port into this frame I'm not going to quibble over a millimetre or two.





Core blimey

Dell opts for Intel's Core Ultra 200V family of chips, complete with vPro support for easier remote management. Which you choose also determines the amount of RAM, as this is built into the package. The Core Ultra 5 236V sits at the bottom and comes with 16GB, the Core Ultra 7 266V has faster clocks and again includes 16GB of RAM, while the Core Ultra 268V is the same power as the 256V but includes 32GB of RAM.

ABOVE Dell's Pro 13 Premium certainly lives up to its name

"This laptop feels so sturdy, so dense, that I would fear for my life if someone came at me swinging with it. Despite this, it won't weigh you down"

BELOW The 1.1kg chassis is sturdy and wonderfully compact

None of these processors is designed for core-intensive tasks, so if you want to edit 10-bit 8K HDR video then move along. Instead, they're best suited for office duties. They each have four high-performance P-cores and four low-power efficiency LPE-cores, with no Hyper-Threading and thus eight threads in total. For most people, most of the time, this matters not one jot. Whichever chip you choose, Windows 11, Chrome and Excel will speed along.

It's only when you benchmark this chip that it can seem slow, with my test unit – based on a 268V and 32GB of RAM – returning an excellent 2,843 in Geekbench 6's single-core test and a solid but unexceptional 11,072 in the multicore test. Cinebench 2024 exposes its lack of threads too, with 126 in the single-core task but only 653 in the multicore section.

Battery bonanza

The payback for this lack of screaming power is battery life. Under light use, with the screen set to 150cd/m², it lasted for a staggering 24hrs 18mins. The other good news is that you can take it from empty to almost 50% in half an hour, with an hour's charge pushing it close to 90%.

I suspect that if the Dell Pro 13 Premium became your everyday laptop you'd simply stop bringing the charger with you for overnight trips. There's no need. Plus it's larger than ideal, with Dell sticking with the two-part design for its chargers. Fortunately, any 65W power source over USB-C will do the job.

These results were based on the three-cell 60Wh battery, and you can choose a two-cell 40Wh variant, which saves around 60 grams of weight and a few pounds. Hardly worth it.

Low-power panel

Another reason for this laptop's spectacular battery life is that Dell includes a low-power panel here. You can choose between three displays, but from previous experience I suggest you avoid the cheapest version with a peak brightness of 300cd/m² and miserly 45% NTSC coverage. My test unit featured the mid-range choice, with a stated peak of 400cd/m² (I measured 442cd/m²) and the promise of 100% sRGB coverage. It came very close to this (98%), but perhaps more importantly covers 78% of the DCI-P3 gamut and that means colours look compelling. An average Delta E of 0.3 underlines its excellent colour accuracy, too.

Dell also sells a touchscreen version that pushes brightness over the 500cd/m² mark, and as it only adds £42 to the price – using Dell's configurator – this is definitely worth considering. I suspect it will consume more power, not least because it has a 2,560 x 1,600 resolution rather than the 1,920 x 1,200 of the other two panels, but you're still going to enjoy excellent battery life.

Your choice of panel will have an effect on the bundled webcam, with the cheapest panel shipping with the cheapest webcam, which means you don't get the presence detection offered with the two other panels. But they all include IR for quick Windows Hello logins and the benefit of eight megapixels for a sharp image. You'll make an excellent impression on fellow web callers, and naturally you can call upon the NPU to add blurring effects independent of the app.

Born entertainer?

The microphone is again top-notch, capturing my voice's every timbre, and Dell invests in top-quality speakers, too. Two are bottom-firing speakers and thus work best when the laptop is sitting on a solid surface like a desk, while the other two are on either side of the keyboard. Other laptops pack more speakers still, but there's enough bass and detail here to make listening to music a pleasure while you tap away.

There's gaming potential here, too, with a 4,454 in 3DMark Time Spy right up with the highest I've seen from integrated graphics. At Low graphics settings and the panel's native 1200p resolution, the Dell returned 52fps in *Shadow of the Tomb Raider* and 53fps in *Dirt 5*. After-hours fun is to be had.

I can't heap equal praise on the keyboard, which has attractive points – solid travel, good layout including a double-height Enter key (for the UK version) and excellent backlighting – but lacks the subtle cushioning of the best laptop keyboards. Still, I could easily imagine bashing out thousands of words on the Dell Pro 13 Premium, so don't wish to be overly harsh.

For an extra £34, you can add Dell's Collaboration Touchpad, which includes four hidden icons that spring into life during Teams and Zoom calls. Tapping the camera icon switches the webcam on or off, likewise the chat, screen share and mic buttons. As there's a mic button on the keyboard (F4) and a physical screen cover for the webcam, it's hardly a must-have.

Configure to win

Dell provides numerous other configuration options. You can choose between 256GB, 512GB and 1TB of storage (our 1TB unit averaged 5,148MB/sec sequential reads and 4,520MB/sec writes); stick with Wi-Fi 7 and Bluetooth 5.4 or embrace the wireless lifestyle with built-in 5G for another £205.

The price above includes Dell's standard ProSupport cover, which includes a three-year warranty with next-day on-site repair (after remote diagnosis). Pay another £97 and you can enjoy accidental damage cover and priority service.

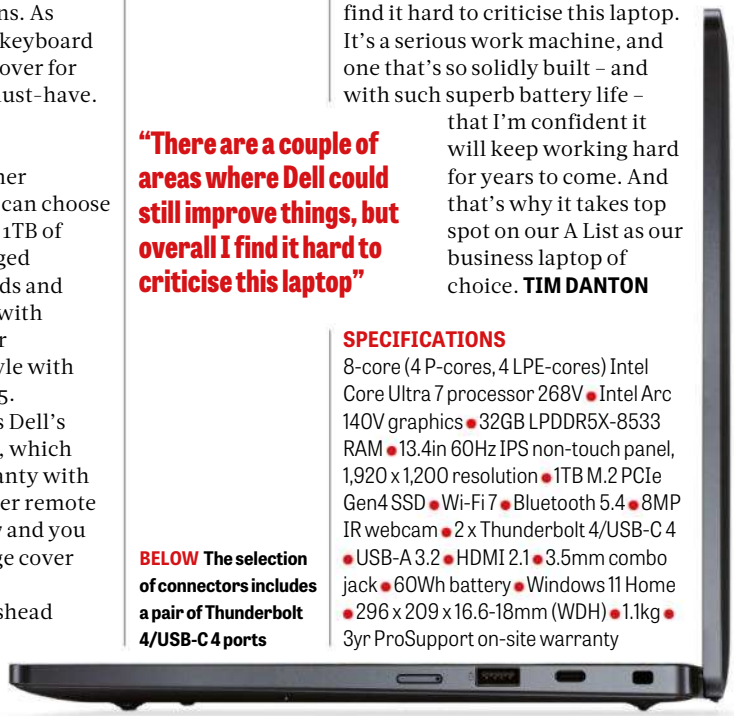
With seven captive crosshead screws securing the base it's ludicrously easy to get inside, but repairs are clearly geared towards professionals rather than amateurs. Black tape covers most areas and while there are QR codes to guide you, this is a job best left to those who repair laptops for a living. Even replacing the battery looks fiddly.

So there are of areas where Dell could improve things, but overall I find it hard to criticise this laptop. It's a serious work machine, and one that's so solidly built – and with such superb battery life – that I'm confident it will keep working hard for years to come. And that's why it takes top spot on our A List as our business laptop of choice. **TIM DANTON**

"There are a couple of areas where Dell could still improve things, but overall I find it hard to criticise this laptop"

LEFT Four icons on the optional Collaboration Touchpad light up for web calls

BELOW The selection of connectors includes a pair of Thunderbolt 4/USB-C 4 ports



SPECIFICATIONS

8-core (4 P-cores, 4 LPE-cores) Intel Core Ultra 7 processor 268V • Intel Arc 140V graphics • 32GB LPDDR5X-8533 RAM • 13.4in 60Hz IPS non-touch panel, 1,920 x 1,200 resolution • 1TB M.2 PCIe Gen4 SSD • Wi-Fi 7 • Bluetooth 5.4 • 8MP IR webcam • 2 x Thunderbolt 4/USB-C 4 • USB-A 3.2 • HDMI 2.1 • 3.5mm combo jack • 60Wh battery • Windows 11 Home • 296 x 209 x 16.6-18mm (WDH) • 1.1kg • 3yr ProSupport on-site warranty

DELL'S NEW BRANDING

Dell announced a fresh approach to laptop and PC branding at CES 2025. Farewell Inspiron and XPS, so long Latitude and Precision. In their place comes a simpler scheme that Dell insists will make it easier for your average laptop or PC buyer to understand.

It's hard to disagree that "Pro" makes more sense for Dell's business-targeted kit than the "Latitude" it essentially replaces. You could even argue that "Premium" is a better moniker than "XPS" to denote top build quality. In isolation, it's perfectly logical for "Pro Max" to replace "Precision" to indicate top levels of performance.

Things become confusing when two similar words sit next to each other in a product name, especially as Dell offers "Plus" variants. Dell says you have a base product (think Inspiron); one better is Dell Plus (such as the Inspiron Plus in old money); Dell Premium is the best. But that results in model names such as Dell Pro 13 Plus and Dell Pro 13 Premium, which will surely confuse the buyers Dell is trying to woo.

Ultimately, time will tell. It's not as if Inspiron, XPS, Latitude or Precision had any inherent meaning, after all.

DELL'S NEW BRANDING IN ONE SIMPLE TABLE

Category	Target audience	Previous equivalent laptop brands
Dell	Consumer, SMB	Inspiron, XPS
Dell Pro	SMB, commercial	XPS, Latitude
Dell Pro Max	Performance	Precision

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SCAN

Lenovo ThinkPad X9 14in Aura Edition

Breaks new ground with ThinkPad design, but it's a shame Lenovo didn't include a bigger battery

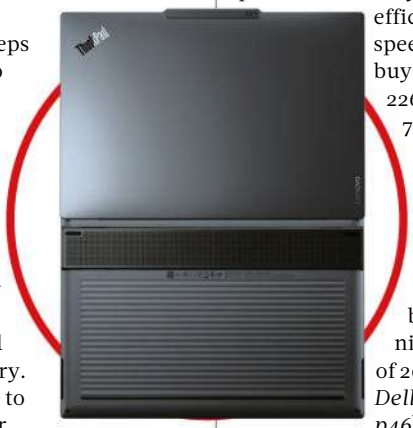
SCORE ★★★★☆

PRICE As reviewed, £1,416 (£1,700 inc VAT) from lenovo.com

Do not adjust your sets: this is a ThinkPad. It's not black, there's no TrackPoint and everything is going to be okay. That's partially because you, if you're already a ThinkPad fan, are not who Lenovo is targeting here: it's trying to reach a new market of young buyers who naturally lean to MacBooks.

Some things stay the same. The build quality is excellent throughout, and all the usual support tools for SMBs and enterprises remain intact. It comes with an excellent three-year warranty, and it's simple to extend this using Lenovo's Commercial Vantage software.

Lenovo also keeps its commitment to sustainability by using recycled materials where it can: 50% recycled aluminium in the chassis, recycled plastics in the keycaps and other plastic materials, and 100% recycled cobalt in the battery. While I would like to see more customer replaceable units – limited here to the M.2 SSD and the 55Wh battery – it couldn't be easier to remove the base.



LEFT **The base features a raised area to house the cooling for the CPU**

Engine room

If you do this then it's impossible to miss a raised, black area that contains the processing power. It's an idea borrowed from gaming laptops, which often shove the CPU and graphics chip to the rear where they can easily direct air through it as rapidly as possible. It also means Lenovo can keep the profile to a super-slender 6.7mm at the front.

Two fans keep Intel's Core Ultra 200V chips working at optimum speeds. This family is designed for efficiency rather than speed: whether you buy the Core Ultra 5 226V or the Core Ultra 7 258V in my test system, it only has four P-cores and four Low-Power Efficiency cores.

That's why I expected better battery life than nine hours. In this era of 20+ hours, (*see the Dell Pro Premium on p46*), that's frankly too little. And it's the main reason the X9 doesn't earn a Recommended award.

I hoped that the dedicated cooling area might lead to the best scores I'd seen from a Core Ultra 7 258V laptop, but it wasn't to be. Instead, it sits in the middle of the pack, roughly level with the Dell XPS 13 (*see issue 365, p51*).

That means the X9 is a great performer in single-core tasks, as shown by 120 in Cinebench 2024 and 2,762 in Geekbench 6. But while Lenovo's multicore scores of 562 in Cinebench and 10,644 in Geekbench are solid, and again similar to Dell's, this will never be a CPU (or laptop) suited to demanding multicore tasks.

Fortunately, it has a couple of other skills. Top of that list is Intel's Arc 140V graphics, which continue to set the pace for integrated GPUs. Here, that showed itself in a 3,942 score in 3DMark Time Spy and averages of 50fps and 49fps in *Shadow of the Tomb Raider* (1080p, Low) and *Dirt 5* (1200p, Low).

The other not-so-hidden talent is Intel's NPU, rated at 47 TOPS. That breezes past the 40 TOPS minimum Microsoft requires for Copilot+ PC status, so you can expect to see Recall arrive on this laptop in a Windows update. For now, it means basic generative AI for creating pictures based on prompts, live translation and extra blurring effects in video calls.

As the X9 is part of Lenovo's Aura Edition family, it includes a few useful (and less useful) extras. For a start, it can spot if someone is lurking over your shoulder and blur your screen. There's also a Wellness Mode to alert you to slouching behaviour or the fact you've been staring at the display for too long. There's also the ability to tap your phone against the side of the screen to instantly transfer photos.

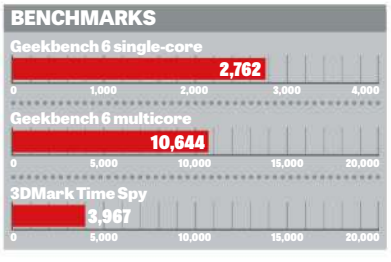
"There are plenty of extras Lenovo can point to that the MacBook Pro doesn't have. Top of the list is a touchscreen"

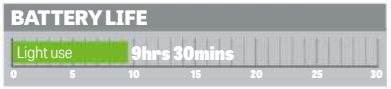
X9 ex TrackPoint

One of the benefits of dropping the TrackPoint, and the two physical buttons that sit above other ThinkPads' touchpads, is that it allows Lenovo to make the X9's touchpad larger and introduce haptic technology. This is an excellent implementation, to the point that it genuinely feels like the touchpad is moving under your finger, when that's simply a clever haptic effect.

ABOVE **The touchpad is larger than previous ThinkPads and uses haptic technology**

BELOW **Lenovo is targeting MacBook fans with its new range of ThinkPads**





Lenovo has also redesigned the keyboard. To my eyes, it's a step backwards towards bland conformity with every other chiclet design. But when I put this to a product manager at CES, he explained that Lenovo is responding to what the market wants: while he couldn't quite bring himself to say "MacBook", the similarity between the two ranges goes beyond the industrial grey finish down to the look of the keyboard.

All is not lost. Lenovo still includes a solid 1.35mm of travel, and while the keys' movement isn't as cushioned as I like there's a solidity to each press thanks to the firm backplate. Lenovo has also worked hard to make this keyboard quiet, while the gentlest of concave recesses on each keycap help guide fingertips and stop them from slipping. Lenovo also gets the basics right, with a double-height Enter key, large spacebar and wide Delete key.

Mac beater

There are plenty of extras Lenovo can point to that the MacBook Pro doesn't have. Top of the list is a touchscreen, and this sharp, punchy AMOLED panel sailed through our tests. It covers 100% of the DCI-P3 colour space and as a result games and films look amazing. A well-balanced set of speakers with respectable levels of bass help drive atmosphere, too.

Lenovo has wireless bragging rights thanks to support for Wi-Fi 7 rather than Wi-Fi 6E, but otherwise connectivity is restricted to two Thunderbolt 4 ports (MacBook Pros include three Thunderbolt 5 ports), HDMI 2.1 and a 3.5mm combo jack. So no USB-A ports here, nor an SD card slot to match its Apple rival.

Apple arguably also has a better camera offering thanks to its Center Stage capability, but there's a simplicity to the high-quality 8MP sensor Lenovo provides. It captures all the detail and colour you need, with superb blurring thanks to the NPU.

Lenovo includes its own AI assistant, Lenovo AI Now, which can create an archive based on locally stored documents you can search using natural language. Or you can create your own knowledge base from docs you import directly into the app. It's still early days for these local AI apps, but there are already potential rewards if you're willing to invest effort.

LEFT **There are two Thunderbolt 4 ports, as well as Wi-Fi 7**

"I doubt Lenovo has done enough here to win over MacBook Pro owners, but for Windows loyalists there's plenty to like"

BELOW **The AMOLED touchscreen sailed through our tests**

Hard to fault

I doubt Lenovo has done enough here to win over MacBook Pro owners, but for Windows loyalists who might otherwise lean towards Dell or HP, there's plenty to like (other than battery life). You can't argue with the quality of the design, nor with the value, with the price here including a 1TB SSD and 32GB of RAM.

It's a solid first outing for the X9, and I suspect it marks the slow evolution away from the ThinkPad's trademark all-black design. Plus ça change. **TIM DANTON**

SPECIFICATIONS

8-core (4 P-cores, 4 LPE-cores) Intel Core Ultra 7 258V processor • Intel Arc 140V graphics • 32GB LPDDR5x-8533 RAM • 14in 120Hz AMOLED touchscreeen, 2,880 x 1,800 resolution • 1TB M.2 PCIe Gen 4 SSD • Wi-Fi 7 • Bluetooth 5.4 • 8MP IR webcam • 2 x Thunderbolt 4/USB-C 4 • HDMI 2.1 • 3.5mm combo jack • 55Wh battery • Windows 11 Pro • 312 x 212 x 6.7-17.2mm (WDH) • 1.3kg • 3yr Premier on-site warranty

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SCAN ME

Asus Zenbook Duo UX8406CA

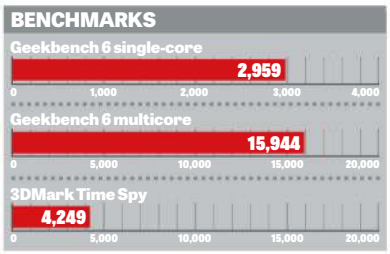
A welcome update to Asus' dual-screen laptop design, and it's faster than ever thanks to Intel's Core 9 Ultra

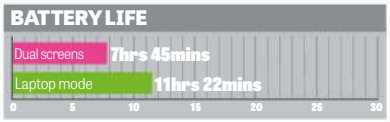
SCORE ★★★★☆

PRICE £1,750 (£2,100 inc VAT)
from uk.asus.com

Turn to our coverage from MWC Barcelona 2025 (*see p12*) and you'll discover that Lenovo continues to hunt for a solution to a perennial laptop problem: how to increase screen area. It provided two solutions, one involving magnetic clip-on displays (which work surprisingly well) and one where the OLED panel folds backwards over the lid. It's a design I'm sure Salvador Dali would have appreciated. This is all on top of Lenovo's forthcoming ThinkBook Plus Gen 6, where a motor unrolls an extra 4.7in of AMOLED screen that's otherwise hidden beneath the keyboard.

All ingenious solutions, but expensive: the ThinkBook is likely to cost £3,500 on its June release. Asus takes a different approach, with its third iteration on the Zenbook Duo elegant in its simplicity. In general use, this is a typical 14in laptop.





When you want to double the screen space, you simply lift off the slim Bluetooth keyboard – it's kept in place by magnets – to reveal a second 14in OLED panel sitting below.

Multi-modal design

Asus has built a kickstand into the Zenbook Duo's bottom half, which means it can elevate to form a double-height display as shown above. You have options when it comes to angles: the stand can push back to around 40° or sit almost at a right angle, which might be necessary if you using the double-height screen on a plane.

You can also sit the Zenbook Duo on its side, in landscape rather than portrait mode, but this is clunky. The right-hand screen floats millimetres above the table the laptop is sitting on, as the weight falls onto the left-hand side (where the kickstand is). It's also more difficult to ignore the 25mm gap between the two panels. It's a far cry from the all-in-one style design of the Asus Zenbook 17 Fold (*see issue 338, p50*) or Lenovo X1 Fold (*see issue 355, p56*), both of which are based around a single, giant OLED screen that folds in the middle.

Asus also pushes the idea of a share mode, where you lay the screens flat with one facing you and the other side facing someone sitting opposite. It then flips the second screen and mirrors them, so you each see exactly the same view. Potentially useful if you need to run through documentation together, and this is the point you might take advantage of the bundled Asus Pen stylus to annotate on-screen documents.

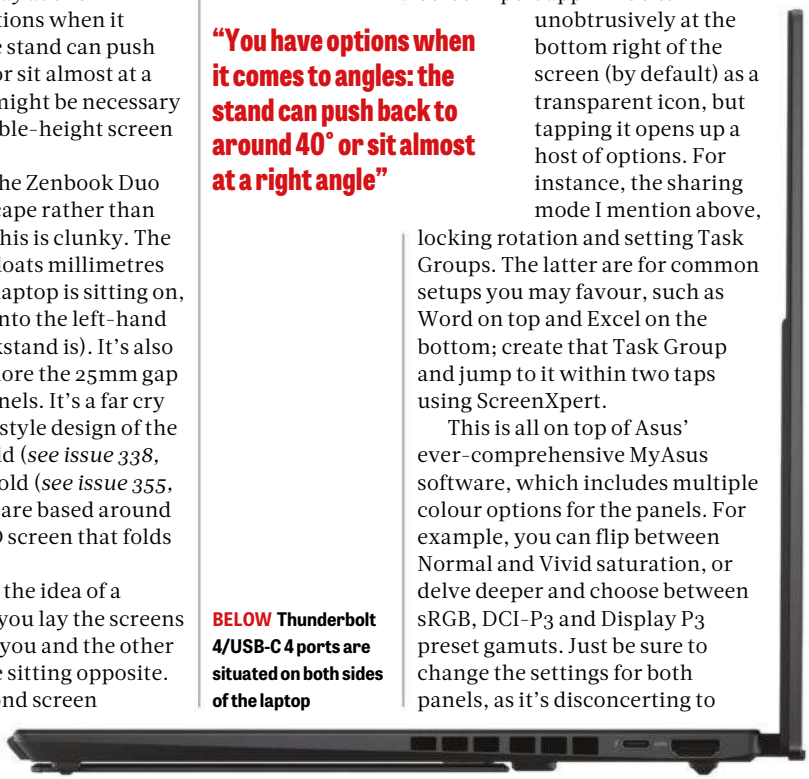
ABOVE **The Asus Zenbook Duo doubles the screen space when you need it**

Become a ScreenXpert

To give you more control than Windows allows, Asus includes its ScreenXpert app. This sits unobtrusively at the bottom right of the screen (by default) as a transparent icon, but tapping it opens up a host of options. For instance, the sharing mode I mention above, locking rotation and setting Task Groups. The latter are for common setups you may favour, such as Word on top and Excel on the bottom; create that Task Group and jump to it within two taps using ScreenXpert.

"You have options when it comes to angles: the stand can push back to around 40° or sit almost at a right angle"

This is all on top of Asus' ever-comprehensive MyAsus software, which includes multiple colour options for the panels. For example, you can flip between Normal and Vivid saturation, or delve deeper and choose between sRGB, DCI-P3 and Display P3 preset gamuts. Just be sure to change the settings for both panels, as it's disconcerting to



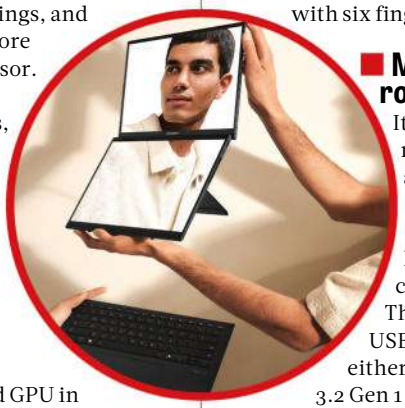
BELOW **Thunderbolt 4/USB-C 4 ports are situated on both sides of the laptop**

oscillate between two colour spaces unless you're doing so for a reason.

Asus has done an excellent job of colour-matching the displays, with a maximum of 2% difference between them when I measured across the colour spaces. I preferred using the panels in their native settings, where they both covered 100% of the DCI-P3 space with an average Delta E of 0.41 on the top panel and 0.42 on the bottom. Colour temperature was almost identical, with 6374K versus 6399K. Both are tremendous examples of AMOLED displays at their best, and with an adaptive refresh rate (up to 120Hz) using Windows feels smooth.

Power play

Of course it helps to have Intel's latest silicon powering things, and here that means a Core Ultra 9 285H processor. This 16-core chip, includes six P-cores, so it's well suited to demanding tasks – a fact reflected in its multicore returns of 15,944 in Geekbench 6 and 939 in Cinebench 2024.



It also packs a powerful integrated GPU in the Arc 140T, which delivered 4,249 in 3DMark Time Spy and powered the Zenbook Duo to40fps in *Dirt 5* at 1200p High settings and 41fps in *Shadow of the Tomb Raider* at 1080p High. Dropping down to Lowest settings ensured both games were playable at the screens' native resolution of 2,880 x 1,800 (you can only play on one screen, not across both), with results of 43fps and 36fps respectively.

Anyone hoping to take advantage of Microsoft's Copilot+ PC skills will be left disappointed as the 285H chip is based on Intel's Arrow Lake architecture, and that means a first-generation NPU rated at 13 TOPS. Microsoft set a 40 TOPS minimum for NPUs in Copilot+, so here Intel's neural chip will spend most of its time blurring video backgrounds. Still, the GPU (which has a 77 TOPS rating) can be called into action by creative apps, so local generative AI is possible.

Laptop life

For all its talents, most of the time the Zenbook Duo will surely spend its life as a laptop with the keyboard sitting atop the second screen. With this in place, it's surprisingly easy to forget what's underneath. Sure, the bottom half of the Zenbook Duo is thicker than most modern laptops, but not to the point of it being obvious or uncomfortable. There's still plenty of travel on the keys, with backlighting on call when you need it. Some typists might not like the single-height Enter key, but I faced no problems when typing.

A slick glass touchpad sits beneath and it has one clever talent: grab hold of a window and you can flick it up or down to fill the top/bottom screen. I can see myself getting used to that over time. There are many more gesture shortcuts to learn that work directly on the screen, including pressing down with three fingers to bring up a virtual touchpad and summoning the virtual keyboard with six fingers.

Mundane routine

It seems almost mundane to talk about the more typical elements of a laptop, but let's start with connectivity. A Thunderbolt 4/USB-C 4 port sits on either side, with a USB-A 3.2 Gen 1 and 3.5mm jack on the left and an HDMI 2.1 output on the right. All predictable enough, as is the presence of Wi-Fi 7 and Bluetooth 5.4 on such a premium machine. There's also a USB-C port in the keyboard, which you'll need to (very occasionally) charge it.

Asus includes a high-quality 1080p webcam, complete with IR sensor for Windows Hello logins, and although its colours are subdued I'd be more than happy to use this for professional video calls. It helps that it sits above the top display, so you can vary its height depending upon the angle of the kickstand.

The Zenbook Duo also captures audio clearly, but as ever with Asus laptops it's worth heading into the MyAsus settings to choose the noise-reduction option that works best for your setting. Likewise the speakers, with a big range of presets along with custom settings. However, whichever setting I chose, I found trebles dominated in tracks such as "Englishman in New York". There's no shortage of bass, though.

Value for money

Asus is only selling one variant of the Zenbook Duo in the UK, the UX8406CA-PZ134W for £2,100 including VAT. If you see a lower-priced version then you may discover it's last year's model, the UX8406MA, which includes a lesser processor but is otherwise very similar.

Considering the innovation and the extra hardware, £2,100 is a fair price, if hardly a bargain. You're paying a hefty premium for the second screen when you compare this laptop to Asus' own Zenbook S 14 UX5406, which costs £1,500 and otherwise has similar specifications.

"Considering the innovation and the extra hardware, £2,100 is a fair price – but it's no bargain. You're paying a hefty premium for the second screen"

There's a 500g weight penalty, too, while its battery life is nothing special in laptop or dual-screen modes.

The Zenbook Duo is also harder to repair than most due to its twin-screen design; it's certainly beyond my skill level to replace the 2TB SSD. It's a shame, then, that Asus doesn't provide a more generous warranty than one year. Head into MyAsus and you can extend this to three years of cover for £88.

Only you will know if the second screen is worth the price, weight and potential repair hassle. What I can say is that Asus hasn't only come up with an innovative design, it's also executed it brilliantly. **TIM DANTON**

LEFT There's also a USB-A 3.2 Gen 1 and 3.5mm jack on the left-hand side

RIGHT The Zenbook Duo is well suited to life as an everyday laptop

LEFT The slim Bluetooth keyboard can be easily detached

SPECIFICATIONS

16-core (6 P-cores, 8 E-cores, 2 LPE-cores) Intel Core Ultra 9 285H • Intel Arc 140T graphics • 32GB LPDDR5X-8400 RAM • 2 x 14in 120Hz OLED touchscreens, 2,880 x 1,800 resolution • 2TB M.2 PCIe Gen4 SSD • Wi-Fi 6E • Bluetooth 5.3 • 1080p IR webcam • 2 x Thunderbolt 4/USB-C 4 • USB-A 3.2 Gen 1 • HDMI 2.1 • 3.5mm headphone jack • 75Wh battery • Asus Pen • Windows 11 Home • 314 x 218 x 14.6-19.9mm (WDH) • 1.7kg (1.4kg system, 327g keyboard • 1yr RTB warranty • part code, UX8406CA-PZ134W

Apple MacBook Air M4

The design stays the same, but a tempting price and speedy M4 chip make the Air a better choice than ever

SCORE ★★★★★

PRICE 13in, from £833 (£999 inc VAT); 15in, from £999 (£1,199 inc VAT) **from** apple.com/uk

How do you make one of the best laptops in the world better? You could redesign it, but you risk disenfranchising passionate fans. In that case, making small changes, especially under-the-hood ones, is the smart move, and it's clearly Apple's strategy here.

The M4 MacBook Air is virtually indistinguishable from the M3 model. Apple has left the keyboard and trackpad almost untouched, and the same goes for the display. The weight of both 13in and 15in variants remains unchanged, so all that's new is a Sky Blue colour option.

The significant changes are all inside. First up, the 12MP Center Stage camera replaces the 1080p FaceTime camera. It's an ultrawide lens in a screen notch that can keep you in the frame during video calls. Then there's the 10-core M4 chip, which adds cores and performance over the M3 despite being based on the same 3nm design.

Lower price!

The biggest change is to the price. Apple has doubled the base unified memory from 8GB to 16GB while reducing the cost to £999 inc VAT for the 13in model. That's as shocking a turn of events as it is welcome, though Apple more than gets its money back if you want more than 256GB of storage: doubling that to 512GB costs another £200, albeit with an upgrade in GPU cores from eight to ten. Every upgrade to memory and storage from this point adds another £200, so if you spec the 13in laptop with 32GB of unified memory and a 2TB SSD you're looking at a juicy £2,199.

It's a similar story for the 15in MacBook Air, although here the baseline model costs £1,199 and includes the 10-GPU Apple chip from the off. In terms of benchmarks, the Air M4 is not at its best in games, languishing at 19fps in *Borderlands 3* and *Total War: Warhammer III* at 1200p, and only reaching 31fps in *Shadow of the Tomb Raider*.

However, when I played the AAA game *Lies of Pi* at maximum settings it was smooth as butter, thanks in part to the new Game Mode, which optimises performance for gaming.

Elsewhere, this is a fast system. I had no trouble editing four 4K 30fps streams at once in Final Cut Pro, but when I loaded up four 4K 120fps clips I noticed stuttering on video playback. Then again, this is a MacBook Air, not a MacBook Pro. And that is one of the key points: if you want the fastest MacBook around, you need to pay for a MacBook Pro with an M4 Pro or M4 Max. The rewards are obvious in the graphs opposite.

Design change?

Some people still mourn the passing of the original MacBook Air's wedge design, the one that started at more than 16.1mm at one end and ended at 4.1mm at the other. I've moved on. At 304 x 215 x 11.3mm, the 13in MacBook Air M4 is thinner than the original MacBook Air was at its thickest point. This is a laptop built for your backpack and, at 1.2kg, light enough that you might forget it's there. Even if you opt for the 15in version it's a reasonable 1.5kg.

ABOVE The MacBook Air is unchanged on the outside, but the price has been slashed

PC PRO RECOMMENDED

LEFT The Touch ID button lets you log in with your fingertips

"Everything about the MacBook Air M4 feels premium. It's a finely machined, eye-catching piece of hardware"

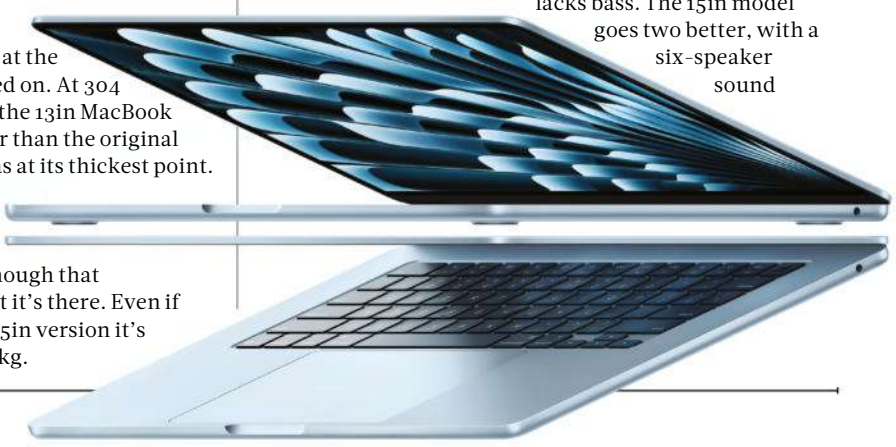
Everything about the MacBook Air M4 feels premium. The 100% recycled aluminium enclosure is solid and has all the exacting tolerances Apple is known for. It's a finely machined, eye-catching piece of hardware, and few laptops match its elegance.

The backlit keyboard is a pleasure to type on, and has remarkable travel and response for such a thin design. It includes a multipurpose power/sleep/Touch ID button that's useful for unlocking the laptop and logging into apps and services with your fingertips. One minor but unifying change is that the mute key now features a speaker icon with a line through it, which matches what you see on-screen when you press the key.

Ports are unchanged from the previous two MacBook Air generations. There are two Thunderbolt 4 ports on the left side with up to 40Gbits/sec of throughput that are capable of driving two external screens, even with the MacBook Air lid open. Next to those sits the MagSafe charging port, and on the right side the 3.5mm headphone jack.

The 13in Air's four-speaker stereo sound system is hidden in the hinge below the display. It can fill a room with bright, crisp audio, although it lacks bass. The 15in model goes two better, with a six-speaker sound

BELOW The MacBook Air is arguably the most elegant-looking laptop you can buy



system complete with force-cancelling sound woofers. As a result, it delivers a surprisingly immersive soundstage.

Center Stage

The M4 MacBook Air's display is identical to the last generation. The smaller model still features a 13.6in Liquid Retina panel with 2,560 x 1,664 resolution and a peak 500cd/m² of brightness, which in my experience is viewable in direct sunlight. It's a fantastic display for everything from gaming to streaming to content creation. As is the 15.3in version with its 2,880 x 1,864 resolution, giving an identical pixel density of 224 pixels per inch.

There's a notch at the top for the camera, but it's not distracting. And, as mentioned, it now contains Apple's 12MP Center Stage Camera. Behind the lens sits an ultrawide camera that, during videoconferencing, crops to an undistorted rectangle. Then, as you move around, the rectangle moves with you. It worked well as long as I didn't stray too far from the centre. If you need the camera to stay still, you can easily turn Center Stage off.

You also benefit from Apple Intelligence courtesy of the M4's 16-core neural engine. This enables features such as Image Playground, which lets you imagine wild scenes that can include representations of you and others from your Photos library. It's fun to play with, but I wonder when Apple will offer an image-generation platform that enables me to describe a complex scene in a prompt and get a result? Here, it's falling behind Copilot+ PCs.

Writing Tools, which is available in Apple's native text composition apps such as Notes and Mail, is more useful, especially if you struggle to write clear, cogent sentences. Similarly, Siri enjoys a few nice upgrades, such as the ability to respond to text prompts and better handle broken speech patterns, but it's unable to carry on longer conversations or learn anything about you, and you still can't use it to fully control your MacBook. Promised updates to Siri that would have made it a more able competitor to ChatGPT and Gemini have failed to materialise, but at least Siri can now tap into ChatGPT for more complex queries.

Battery plus

Apple promises up to 18 hours of battery life from both the 13in and 15in MacBook Air, but this simply refers to how long the laptops can play 1080p video for. In reality, longevity depends on the tasks you throw at it.

In my tests, which included playing games (and made the laptop base quite warm), editing video, opening multiple browser tabs and streaming video, battery life came in at around eight hours. That's respectable for a hard day of work, especially for such a thin and light laptop. Switching to our more repeatable but less demanding light-use test, which is based around web browsing, the 13in M4 Air managed 14hrs 51mins. It was a similar story for the 15in Air, which lasted a shade over 15 hours.

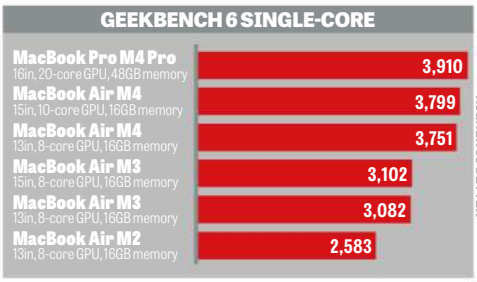
After I drained the laptop to zero, I recharged it with the included 30W charger (the 24GB model comes with a 35W charger) and matching Sky Blue MagSafe charger to 50% in 90 minutes, and 100% in three-and-a-half hours.

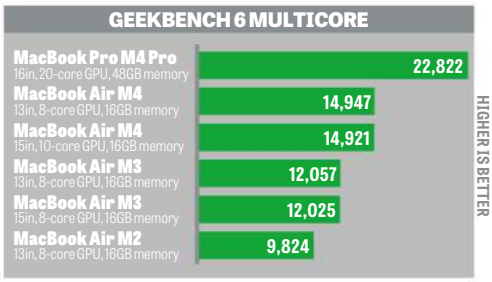
Take some Air?

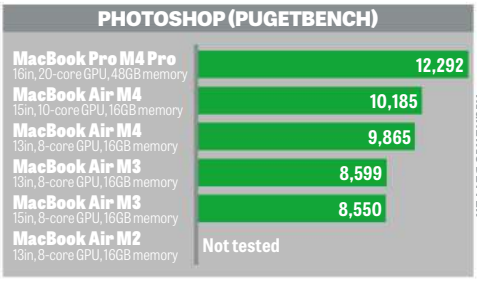
Apple's 13in MacBook Air was my favourite laptop before, and this update confirms it. Its build and design are excellent, working on it is a pleasure and the M4 chip provides all the power I need for the widest range of tasks. I also appreciate the long battery life, colourful screen and clear audio, while I'm relieved Apple has kept the vestigial 3.5mm headphone jack along with the Thunderbolt ports I need to support my almost always connected external screen.

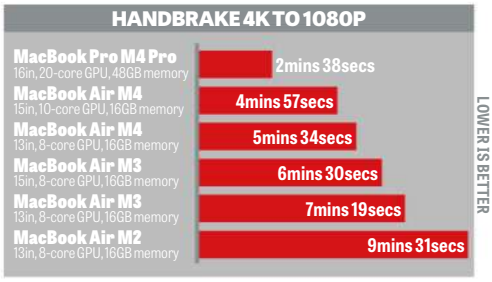
The lower starting price and that lovely new Sky Blue finish only emphasise its quality and appeal. It's only once those upgrades push the price up that Apple opens the door to Windows laptops, with their more varied designs and (for Copilot+ PCs) more impressive local AI skills. While it can't match the M4 Pro power of a MacBook Pro, the Air is all the laptop most people will need. **LANCE ULANOFF**

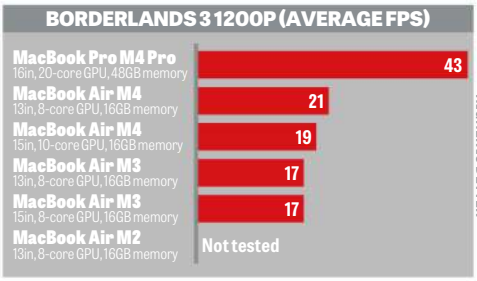
ABOVE The 100% recycled aluminium enclosure is solid as well as classy

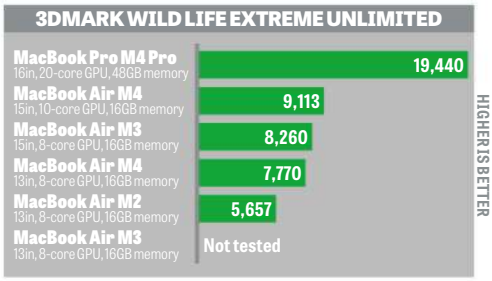

GEEKBENCH 6 SINGLE-CORE
MacBook Pro M4 Pro 16in, 20-core GPU, 48GB memory 3,910
MacBook Air M4 15in, 10-core GPU, 16GB memory 3,799
MacBook Air M4 13in, 8-core GPU, 16GB memory 3,751
MacBook Air M3 15in, 8-core GPU, 16GB memory 3,102
MacBook Air M3 13in, 8-core GPU, 16GB memory 3,082
MacBook Air M2 13in, 8-core GPU, 16GB memory 2,583
HIGHER IS BETTER


GEEKBENCH 6 MULTICORE
MacBook Pro M4 Pro 16in, 20-core GPU, 48GB memory 22,822
MacBook Air M4 13in, 8-core GPU, 16GB memory 14,947
MacBook Air M4 15in, 10-core GPU, 16GB memory 14,921
MacBook Air M3 13in, 8-core GPU, 16GB memory 12,057
MacBook Air M3 15in, 8-core GPU, 16GB memory 12,025
MacBook Air M2 13in, 8-core GPU, 16GB memory 9,824
HIGHER IS BETTER


PHOTOSHOP (PUGETBENCH)
MacBook Pro M4 Pro 16in, 20-core GPU, 48GB memory 12,292
MacBook Air M4 15in, 10-core GPU, 16GB memory 10,185
MacBook Air M4 13in, 8-core GPU, 16GB memory 9,865
MacBook Air M3 13in, 8-core GPU, 16GB memory 8,599
MacBook Air M3 15in, 8-core GPU, 16GB memory 8,550
MacBook Air M2 13in, 8-core GPU, 16GB memory Not tested
HIGHER IS BETTER


HANDBRAKE 4K TO 1080P
MacBook Pro M4 Pro 16in, 20-core GPU, 48GB memory 2mins 38secs
MacBook Air M4 15in, 10-core GPU, 16GB memory 4mins 57secs
MacBook Air M4 13in, 8-core GPU, 16GB memory 5mins 34secs
MacBook Air M3 15in, 8-core GPU, 16GB memory 6mins 30secs
MacBook Air M3 13in, 8-core GPU, 16GB memory 7mins 19secs
MacBook Air M2 13in, 8-core GPU, 16GB memory 9mins 31secs
LOWER IS BETTER


BORDERLANDS 3 1200P (AVERAGE FPS)
MacBook Pro M4 Pro 16in, 20-core GPU, 48GB memory 43
MacBook Air M4 13in, 8-core GPU, 16GB memory 21
MacBook Air M4 15in, 10-core GPU, 16GB memory 19
MacBook Air M3 13in, 8-core GPU, 16GB memory 17
MacBook Air M3 15in, 8-core GPU, 16GB memory 17
MacBook Air M2 13in, 8-core GPU, 16GB memory Not tested
HIGHER IS BETTER


3DMARK WILD LIFE EXTREME UNLIMITED
MacBook Pro M4 Pro 16in, 20-core GPU, 48GB memory 19,440
MacBook Air M4 15in, 10-core GPU, 16GB memory 9,113
MacBook Air M3 15in, 8-core GPU, 16GB memory 8,260
MacBook Air M4 13in, 8-core GPU, 16GB memory 7,770
MacBook Air M2 13in, 8-core GPU, 16GB memory 5,657
MacBook Air M3 13in, 8-core GPU, 16GB memory Not tested
HIGHER IS BETTER

SPECIFICATIONS

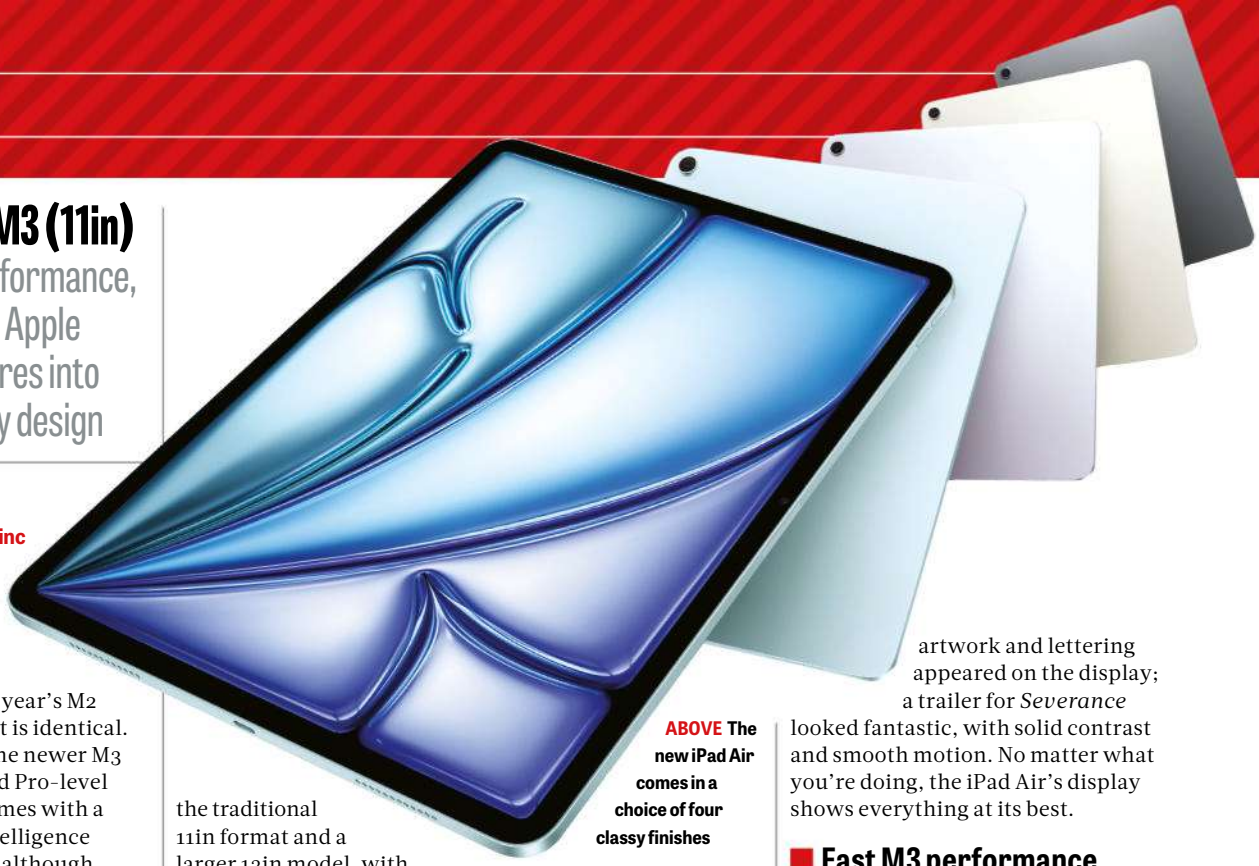
MacBook Air 13in: 13.6in non-touch 60Hz IPS display, 2,560 x 1,664 resolution • 54Wh battery • 304 x 215 x 11.3mm (WDH) • 1.2kg
MacBook Air 15in: 15.3in non-touch 60Hz IPS display, 2,880 x 1,864 resolution • 67Wh battery • 340 x 238 x 11.5mm (WDH) • 1.5kg
Shared: 10-core Apple M4 chip • 16GB/24GB/32GB unified memory • 256GB/512GB/1TB/2TB M.2 PCIe Gen 4 SSD • Wi-Fi 6E • Bluetooth 5.3 • 2 x USB-C 4/Thunderbolt 4 ports • 3.5mm headphone jack • MagSafe 3 charger • 12MP Center Stage webcam • macOS Sequoia • 1yr RTB warranty

Apple iPad Air M3 (11in)

Crams stellar performance, a vivid display and Apple Intelligence features into the familiar skinny design

SCORE ★★★★★

PRICE 128GB, £499 (£599 inc VAT) from apple.com/uk



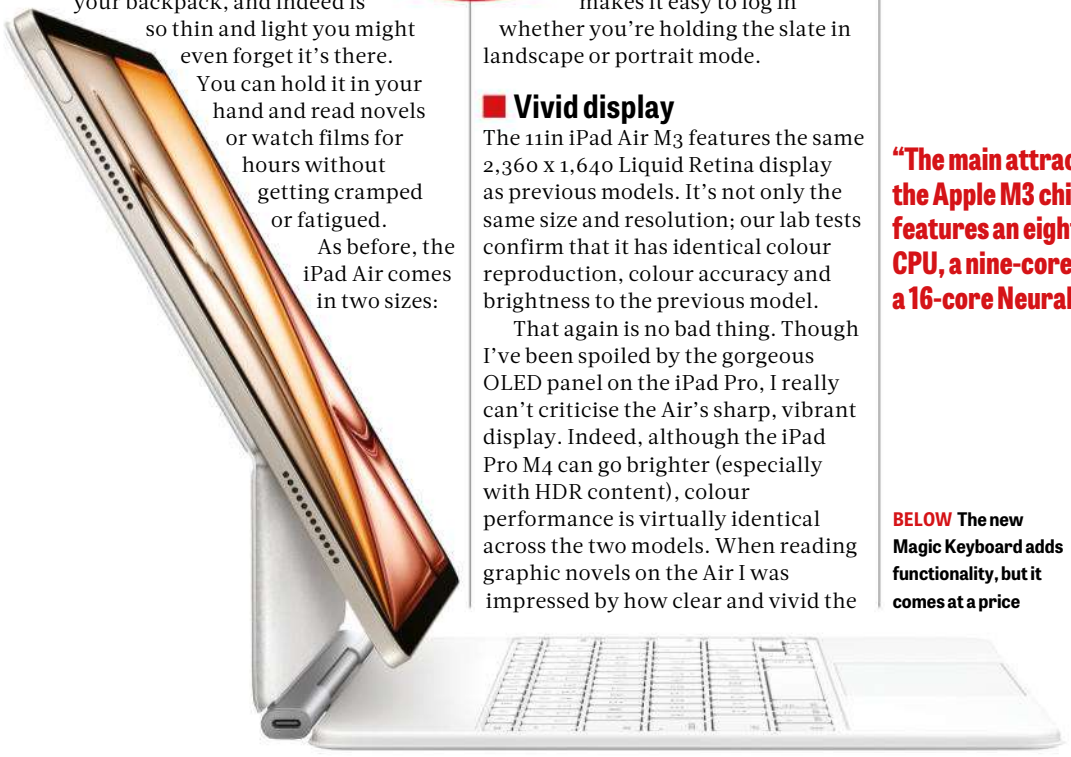
ABOVE The new iPad Air comes in a choice of four classy finishes

Apple's new iPad Air M3 looks identical to last year's M2 model. That's because it is identical. The only difference is the newer M3 chip, which gives it iPad Pro-level performance. It also comes with a host of useful Apple Intelligence features out of the box, although these AI capabilities can also be added to the M2-powered Air by simply upgrading to iPadOS 18.

If you're like me and have previously admired the iPad Air's thin, minimalist aluminium design, you won't mind that Apple hasn't changed it: it's as elegant and sturdy as ever. Measuring a mere 6.1mm deep and weighing only 460g, this tablet still lives up to its "Air" moniker. It can easily slip into your backpack, and indeed is so thin and light you might even forget it's there. You can hold it in your hand and read novels or watch films for hours without getting cramped or fatigued.

As before, the iPad Air comes in two sizes: the traditional 11in format and a larger 13in model, with prices starting at £599 and £799 respectively for 128GB of storage. There's also a choice of four finishes, namely Blue, Purple, Starlight and Space Grey. I'm fond of Blue, but they're all stylish; my review unit's Space Grey looked positively classy.

The downside of the design is that Apple hasn't taken the opportunity to add FaceID. However, you can register multiple fingerprints on the power button, which makes it easy to log in whether you're holding the slate in landscape or portrait mode.



BELOW The new Magic Keyboard adds functionality, but it comes at a price

Vivid display

The 11in iPad Air M3 features the same 2,360 x 1,640 Liquid Retina display as previous models. It's not only the same size and resolution; our lab tests confirm that it has identical colour reproduction, colour accuracy and brightness to the previous model.

That again is no bad thing. Though I've been spoiled by the gorgeous OLED panel on the iPad Pro, I really can't criticise the Air's sharp, vibrant display. Indeed, although the iPad Pro M4 can go brighter (especially with HDR content), colour performance is virtually identical across the two models. When reading graphic novels on the Air I was impressed by how clear and vivid the artwork and lettering appeared on the display; a trailer for *Severance* looked fantastic, with solid contrast and smooth motion. No matter what you're doing, the iPad Air's display shows everything at its best.

PC PRO ★★★★★ A-LIST

LEFT Apple's M3 chip performed extremely well in our tests

Fast M3 performance

As I've mentioned, the main attraction of the new iPad Air is the Apple M3 chip, which features an eight-core CPU, nine-core GPU and 16-core Neural Engine. There's also 8GB of high-speed RAM built into the processor package.

As you'd expect, therefore, the tablet did very well in our performance tests. In Geekbench 6, which focuses on the CPU, the M3-driven iPad Air performed much better than its M2 counterpart with a single-core return of 3,042 and 11,804 multicore result compared to 2,666 and 10,066 respectively. It also demolished Samsung's Galaxy Tab S9 (*see issue 352, p90*), which scored 2,116 and 5,164.

So the iPad Air M3 has power to spare in everyday tasks. It was only when scrolling pages of comics that I noticed it was slower than the iPad Pro, but the overall experience is noticeably faster than on the M2 iPad Air.

"The main attraction is the Apple M3 chip, which features an eight-core CPU, a nine-core GPU and a 16-core Neural Engine"

It's a fine tablet for gaming, too, despite being a fraction slower in the the 3DMark Wild Life benchmark than the M2 model with 5,802 versus 5,829. But even in tough games such as *Resident Evil 4*, the frame rate proved smooth and consistent. In fact, enhancements such as hardware-accelerated mesh shading, ray tracing and dynamic caching helped this game look phenomenal.

Padded out

Apple claims the iPad Air M3's battery offers up to ten hours of web surfing and video streaming. While the tablet didn't last quite that long for us, it came close: with the device's display set to 150cd/m², the iPad Air M3

managed 9hrs 41mins of continuous browsing over Wi-Fi. Curiously that's almost two hours behind the iPad Air M2, but it's 30 minutes longer than the Galaxy Tab S9.

Trying out the 12MP cameras on the front and back of the iPad Air, I was happy to find that both delivered sharp, clear images. They're nowhere near as versatile or detailed as the cameras on an iPhone, but if you simply want to grab everyday snaps or look your best during video calls, you won't be disappointed. I'm also a fan of Apple's recent relocation of the front camera to the long edge, as this makes it easier to position yourself during landscape-mode video calls, especially if you have the M3 Air docked in the optional Magic Keyboard, which we'll discuss below.

Apple Intelligence

The iPad Air M3 comes with a slew of the latest Apple Intelligence features ready for you to try out, from a smarter Siri to tools that can touch up photos, improve your writing and generate images.

My favourite aspect of Apple Intelligence is the writing tools, which can proof-read, rewrite and change the tone of what you've written. For example, you can ask it to make your writing sound more friendly, professional or concise – and if you don't like the result, just hit revert.

Image Playground is another Apple Intelligence feature I enjoyed using on the iPad Air. This generates images based on your prompts and inputs; while its creations aren't photorealistic, it does well at rendering simple pictures. You can either type in your instructions or speak them out loud to Siri.

On that note, speaking with the new Siri is hit or miss. Apple's digital assistant can handle basics such as telling you the weather or a restaurant's location, but it struggled when I asked for personal recommendations, such as what I should have for dinner.

Other Apple Intelligence features include removing things from photos or adding AI-generated images to video projects. There's much to play with, some of it impressive, and it will be interesting to see what other AI capabilities are added in future.

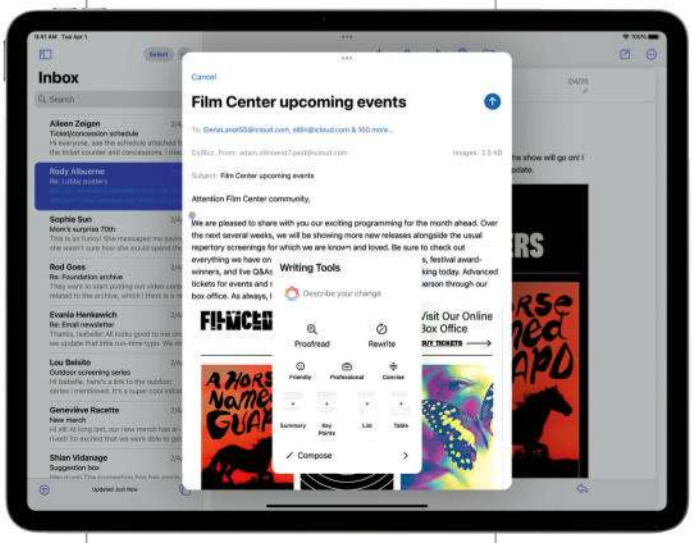
Expensive add-ons

At this point, anyone who currently uses an iPad Pro might be wondering if the M3 Air can meet all their needs. Though barely any different from the M2 model, it does almost everything that Apple's most premium tablet can achieve.

As with the iPad Pro, though, to get the most from it you'll need to invest in peripherals. The most obvious choice is the Apple Pencil, and there are two models that can be used with the iPad Air: the USB-C Pencil does the basic job for £79, but the Pencil Pro will give you a much better experience, since it has extra features such as barrel roll, haptic feedback and squeeze. It also offers wireless charging when magnetically attached to the iPad Air. Unfortunately, it's also pricier at £129.

Another add-on to seriously consider is the new Magic Keyboard for iPad Air. This now has a 14-key function row for instant access to controls such as the volume and screen brightness, along with a larger touchpad that feels more MacBook-like and passthrough USB-C charging.

ABOVE The Magic Keyboard now has a 14-key function row and a bigger touchpad



ABOVE The iPad Air's Apple Intelligence features include useful writing tools

The typing experience isn't half bad, even if you have big hands like I do. The snappy keys have plenty of travel distance, and the responsive touchpad turns the iPad Air into a very usable laptop replacement. The catch again is the price: the version for the 11in Air is £269 inc VAT, while the 13in model is £299 – so there's not much difference in cost between an iPad with a keyboard and one of Apple's new MacBook Airs (*see p54*).

UPGRADE COSTS FROM BASE MODELS

	128GB	256GB	512GB	1TB
iPad Air 11in Wi-Fi	£599	£699	£899	£1,099
iPad Air 13in Wi-Fi	£799	£899	£1,099	£1,299
iPad Air 11in cellular	£749	£849	£1,049	£1,249
iPad Air 13in cellular	£949	£1,049	£1,249	£1,449

All prices inc VAT

M3 marvel?

The iPad Air M3 is hardly a revolutionary upgrade over what came before, but it's still a fantastic device. Watching videos or reading books on its bright and colourful display is a delight, and the boosted performance certainly doesn't hurt. Toss in handy and fun Apple Intelligence features, reliable battery life and a predictably thin and light design, and you have another winning Apple tablet.

Indeed, my only complaint isn't with the iPad Air itself, but with its pricey peripherals. A big part of the iPad's appeal is support for productivity accessories, especially the Apple Pencil Pro and the Magic Keyboard. Buy them both and you're going to being paying well over £900 – or more, depending on which iPad Air model you choose.

Still, the iPad Air remains considerably cheaper than the iPad Pro, while delivering a very similar high-end experience. It's one of the best tablets you can buy, and if you're not on a tight budget this is the iPad I'd recommend to the vast majority of people. **TONY POLANCO**

SPECIFICATIONS

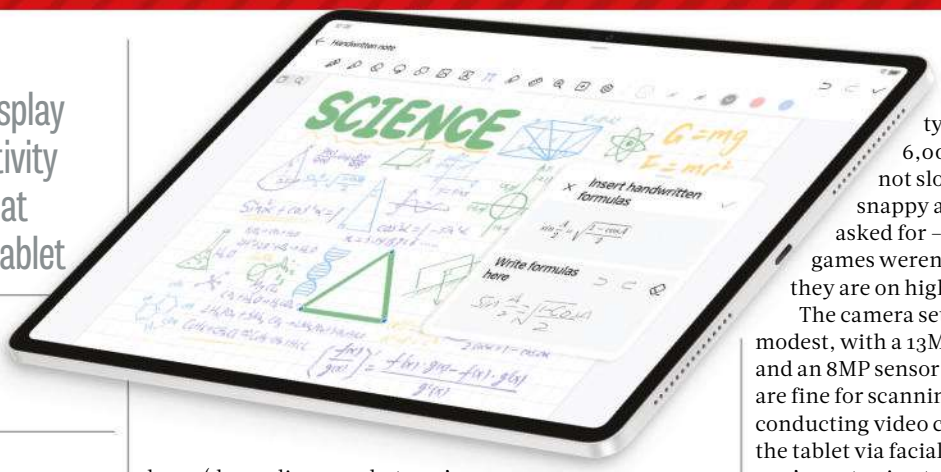
Apple M3 processor • 8GB RAM • 11in IPS touchscreen, 60Hz, 1,640 x 2,360 resolution • 128GB/256GB/512GB/1TB storage • 12MP rear camera • 12MP front camera • Wi-Fi 6E • Bluetooth 5.3 • USB-C 3.2 Gen 2 • 29Wh battery • iPadOS 18 • 179 x 6.1 x 248mm (WDH) • 460g • 1yr RTB warranty

Honor Pad V9

Great audio, a fine display and bundled productivity apps make this a great mid-range Android tablet

SCORE ★★★★☆

PRICE £333 (£400 inc VAT)
from honor.com



The Honor Pad V9 makes an appealing Android-based alternative to the standard iPad. It offers comparable hardware specs along with clever built-in software features – and while it's more expensive than the cheapest model of Apple's tablet, it comes with twice as much storage. Even better, the £400 price includes a flip cover and stylus, both pricey extras for its rival. It's worth mentioning, though, that there's only one model available, with no option for additional storage or cellular connectivity.

The V9's design doesn't shake up the tablet world, nor the colour options of grey and white, but the tablet looks smart with classy rounded edges. A USB-C port sits on the right-hand side with a front camera along the long edge, suitable for video calls. At 6.1mm thick and weighing 475g, it's nicely portable: I found it easy to hold for long enough to watch an entire film in bed. Just be warned that the Honor Pad V9 doesn't have an IP rating against dust or water ingress.

The tablet is pretty big, as mid-range Android tablets go, with the display measuring 11.5in diagonally. It has a sharp native resolution of 2,800 x 1,840 and a fast refresh rate of up to 144Hz, compared to 60Hz for the base iPad. Honor claims a 500cd/m² peak brightness, although it actually goes a fraction higher, and it supports the DCI-P3 gamut with IMAX Enhanced certification. Expect an excellent experience when watching streaming content from Disney Plus and elsewhere.

This extends to the audio: there are a whopping eight speakers hidden around the edges of the V9, while on other tablets you're lucky to get four. This helps create a sense of spacious audio, with the soundstage spread out to the left and right as well as up and down (depending on what you're watching). Not that the maximum volume is deafening: streaming a movie in quiet surroundings is fine, but when I put on Netflix while I was cooking, I struggled to hear what was being said over the bubbling sauces and clanking pans.

Honor's MagicOS 9 is a custom Android 15 setup, but rather than clogging up the interface with a million first-party apps Honor sensibly adds a handful of extras. One is Honor Docs, a suite of Microsoft Office-type productivity apps; there are also handy utilities for converting documents to PDF and managing all the documents on your tablet in one place. Nor has Honor gone overboard with AI features, with a modest collection of tools that add the ability to create meeting minutes from your notes, summarise documents or automatically lay them out neatly. If you're looking for a tablet to use for work, these tools genuinely elevate the Honor above most rivals – and if you already own other Honor devices, your documents can be automatically shared across them.

Inside the Honor Pad V9 boasts a MediaTek Dimensity 8350 Elite chipset. Despite the name, this is a mid-range processor, as reflected by its Geekbench 6 multicore score of 4,409; the best phones and tablets typically hit around 6,000. It's certainly not slow – apps were as snappy as I could have asked for – but high-end games weren't as smooth as they are on high-end devices.

ABOVE The Pad V9 is as well suited to work as it is to pleasure

The camera setup is similarly modest, with a 13MP rear camera and an 8MP sensor on the front. These are fine for scanning documents, conducting video calls and unlocking the tablet via facial recognition, but you're not going to be taking beautiful artistic snaps. My test pictures came out with noticeable noise in darker areas (even in well-lit scenes), and activating portrait mode made no difference at all.

PC PRO RECOMMENDED

The V9's 10,100mAh battery is a similar size to the iPad's, and I found it got me through about two days of heavy use before the tablet needed to be charged. Once I relaxed into a more normal routine – some word processing here, a movie night there, occasional music streaming– I reached about five days of use before needing to plug in.

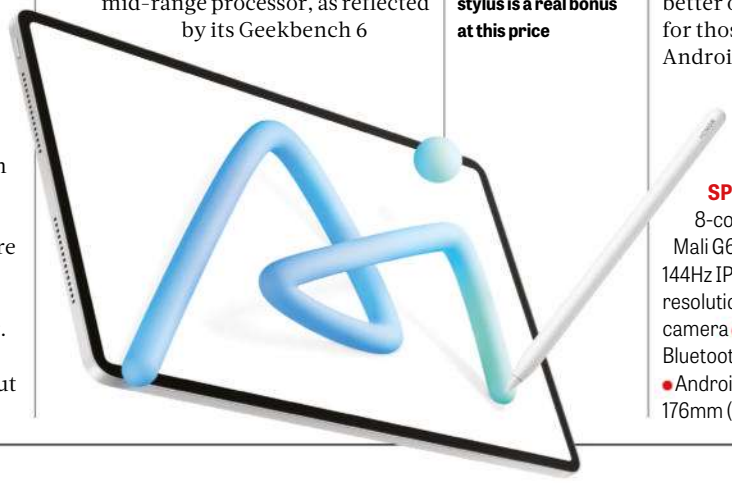
"The included software means you can be productive, and the high-quality screen and speakers make for great entertainment"

This brings me to the most disappointing aspect of my time with the Pad V9. The battery recharges at a maximum rate of 35W, so even with the fastest supported charger you're looking at a wait of several hours to refill it from empty. I found I ended up charging the tablet in dribs and drabs, just to make sure it kept going when I needed it – not a terrible imposition, but not a great experience either.

LEFT The sharp resolution and superb speakers make watching films a joy

In all, though, the more I used the Honor Pad V9, the more I appreciated its strengths. The sensible choice of processor allows for a competitive price, the included software means you can be genuinely productive, and the high-quality screen and speakers make for great entertainment. If you're looking for a creativity powerhouse then you're better off in the Apple ecosystem, but for those who prefer to stick with Android the Honor Pad V9 makes a practical, versatile and affordable big-screen companion. **TOM BEDFORD**

BELOW The bundled stylus is a real bonus at this price



SPECIFICATIONS

8-core MediaTek Dimensity 8350 SoC • Mali G615-MC6 graphics • 8GB RAM • 11.4in 144Hz IPS touchscreen, 2,800 x 1,840 resolution • 256GB storage • 13MP rear camera • 8MP front camera • Wi-Fi 6 • Bluetooth 5.2 • USB-C 2 • 10,100mAh battery • Android 15 with MagicOS 9 • 259 x 6.1 x 176mm (WDH) • 475g • 2yr warranty

palicomp

01270 898 104
sales@palicomp.co.uk

pro-series

mid [PRO1]

£449.99

CPU	AMD RYZEN 5 8500G
Core	6 Cores - 12 Threads
Clock	(3.5/5Ghz Turbo)
Mob	ASUS TUF A620M-PLUS WIFI
RAM	ADATA 16GB DDR5 5600Mhz
M.2	TRANSCEND 1TB M.2 nVME
GPU	AMD RADEON Graphics
Case	KOLINK Observatory HF MESH
O/S	*NO OPERATING SYSTEM*
PSU	BUILDER 500W PSU

Max [PRO2]

£979.99

CPU	AMD RYZEN 5 7600X
Core	6 Cores - 12 Threads
Clock	(4.7/5.3Ghz Turbo)
Mob	ASUS PRIME B650M-A WIFI II
RAM	ADATA 32GB DDR5 5600Mhz
M.2	TRANSCEND 1TB M.2 nVME
GPU	NVIDIA RTX4060 TI 16GB
Case	1stPlayer D3-A aRGB - Black
O/S	*NO OPERATING SYSTEM*
PSU	CIT 700W PSU

UBER [PRO3]

£1159.99

CPU	INTEL Core i5 14600K
Core	14 Cores - 20 Threads
Clock	(2.6/5.3Ghz Turbo)
Mob	ASUS B760M-K
RAM	ADATA 32GB DDR5 5600Mhz
M.2	ADATA 2TB S70 Blade M.2 nVME
GPU	NVIDIA RTX4060 TI 16GB
Case	GAMEMAX F15M MESH
O/S	*NO OPERATING SYSTEM*
PSU	BEQUIET 850W Gold PSU

Aurora RANGE

i3 Aurora [AUR1]

£629.99

CPU	INTEL Core i3 14100F
Core	4 Cores - 8 Threads
Clock	(3.5/4.7GHz)
Mob	ASUS B760M-K
RAM	ADATA 16GB DDR5 5600Mhz
M.2	TRANSCEND 1TB M.2 nVME
GPU	NVIDIA RTX3050 8GB
Case	GAMEMAX Abyss Mini RGB
O/S	MICROSOFT Windows 10/11
PSU	CIT 600W Bronze PSU

i5 Aurora [AUR2]

£999.99

CPU	INTEL i5 14400F
Core	10 Cores - 16 Threads
Clock	(Turbo 4.7Ghz)
Mob	ASUS B760M-K
RAM	CORSAIR 32GB DDR5 6000Mhz
M.2	ADATA 2TB M.2 NVMe
GPU	NVIDIA RTX4060 8GB
Case	CORSAIR iCUE 4000X
O/S	MICROSOFT Windows 10/11
PSU	CORSAIR 650W PSU

i7 Aurora [AUR3]

£1599.99

CPU	INTEL Core i7 14700KF
Core	20 Cores - 28 Threads
Clock	(3.4/5.6Ghz Turbo)
Mob	ASUS PRIME Z790-P WIFI - DDR5
RAM	CORSAIR 32GB DDR5 6000Mhz
M.2	ADATA 1TB S70 Blade M.2 nVME
GPU	NVIDIA RTX4070 12GB
Case	CORSAIR iCUE 4000X RGB
O/S	MICROSOFT Windows 10/11
PSU	CORSAIR 650W Gold PSU

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PCSpecialist Hydra R60S

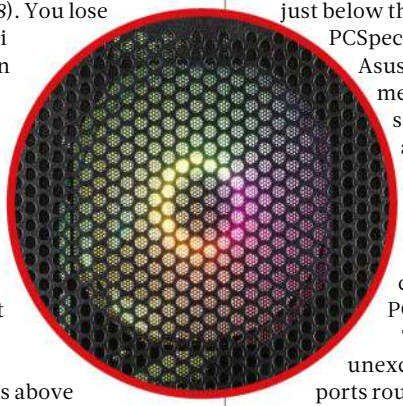
Build around RTX 4060 graphics, this is a compact and quiet PC that majors in value for money

SCORE ★★★★☆

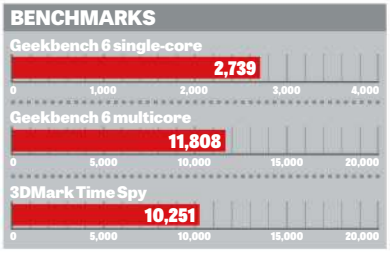
PRICE £833 (£999 inc VAT) from pcspecialist.co.uk/reviews

AMD's Ryzen 9 9950X3D (*see p60*) may be the headline news, but there's much to be said for AMD's older processors. The Ryzen 5 7500F is a great-value six-core chip that continues to hold up well in benchmarks two years after its release, with the Zen 4 architecture delivering the goods for gamers. Six cores and 12 threads means it's more than capable in media-creation tasks, too, with 816 in Cinebench 2024's multicore section a fine score even today.

Meanwhile, Nvidia's RTX 40-series cards have retained their lustre despite the release of the RTX 50-series (*see p68*). You lose out on DLSS Multi Frame Generation and memory bandwidth, but in terms of horsepower there isn't as big a divide between the RTX 40 and RTX 50 series as might be imagined.



If you want to stay at frame rates above 100fps then you may need to stick to 1080p. At High settings, this system averaged 116fps in *Borderlands 3*, 183fps in *Shadow of the Tomb Raider*, 129fps in *Dirt 5* and 128fps in *Cyberpunk*. Switching on ray tracing (RT Ultra) dropped that to 61fps. At 1440p, sticking to High, I saw 82fps in *Borderlands 3*, 132fps in *Shadow of the Tomb Raider*, 99fps in *Dirt 5* and 83fps in *Cyberpunk*. Not bad for £999.



I'd be tempted to double the RAM from 16GB to 32GB, though, with two sockets lying free, and due to the greed of modern games the 1TB SoildIGM SSD may soon be full. There's one empty M.2 2280 socket lying in wait on the Asus Prime B650-Plus motherboard, and it couldn't be easier to access as it sits just below the graphics card.

ABOVE The Hydra R60S is a great-value computer with strong performance in games

PCSpecialist again opts for Asus here, and while this means it's reassuringly solid and well cooled it also obscures one of the board's two PCIe x1 slots. The other one is occupied by an Intel Wi-Fi 6E AX210 card, leaving a single PCIe x16 slot free.

There's a solid but unexceptional collection of ports round the back. It's good to see a USB-C connector but it peaks at 10Gbits/sec (USB 3.2 Gen 2), while there's an over-abundance of USB-A ports; three support 10Gbits/sec, two 5Gbits/sec and two are plain old USB 2. You also benefit from a 2.5GbE port and plenty of audio outputs, including S/PDIF.

This is all wrapped up in one of PCSpecialist's many custom cases, here the PCS Prism II. It's a basic case, but there are no signs of rough edges and it's easy on the eye. What I most appreciate is its size, with a trim 210mm width and 363mm depth meaning it can squeeze into spots other midi tower chassis can't. Removing two thumbscrews (no screwdrivers required here) releases the right-hand panel to reveal two bays for 2.5in SSDs and a 3.5in disk cage. Plenty for most needs.

You'll also discover a high-quality modular Corsair RM 650W power supply, which not only meets Nvidia's recommendations for an RTX 4070 and 5070 but is also one of the quieter PSUs you can buy. That's one reason I didn't hear a single whine from the fans during my tests. This isn't to say this is a silent PC – there's always a faint whirr, and it steps up a notch or two when pushed – but I could happily live with this unit on my desk. Much of the credit for this should go to the chunky PCS-branded air cooler.

The cooler is also the main contributor to colour inside the chassis, supplemented by the 120mm rear fan and two front-mounted fans, all of which are aRGB and controllable via Asus' Armoury Crate software. The front fans shine effectively through the metal grille, with the PCS logo embossed extremely subtly at the bottom of the case. PCSpecialist pitches this chassis as suitable for offices, and while it obviously lacks the easy remote management of the Lenovo ThinkCentre on p64 I can see its appeal to smaller businesses.

This is also where buying British comes into PCSpecialist's favour, along with its consistently excellent ratings for customer support in our annual Excellence Awards. It's backed by a three-year warranty, with the first six months including all courier costs and the first year labour. Hunt around online stores and you may fine a higher-specced PC for around this money – one that even includes an RTX 4060 Ti – but the PCSpecialist Hydra R60S is a well-built system that comes with the reassurance of strong support and next-day delivery. **TIM DANTON**

"Buying British comes into PCSpecialist's favour, along with its consistently excellent ratings in our annual Excellence Awards"

BELOW The compact case can squeeze into spots other PCs can't

SPECIFICATIONS

6-core AMD Ryzen 5 7500F processor • Asus Prime B650-Plus motherboard • 16GB Corsair Vengeance DDR5-5200 RAM • 8GB Nvidia GeForce RTX 4060 graphics • PCS FrostFlow 100 aRGB v3 air cooler • 1TB SolidIGM P41+ M.2 PCIe Gen4 SSD • Intel Wi-Fi 6E AX210 card • PCS Prism II ARGB Mid-Tower Case • 650W Corsair RM PSU • Windows 11 Home • 210 x 363 x 447mm (WDH) • 3yr warranty (6 months C&R, 1yr RTB parts & labour, 2yr labour only) • power: 64W idle, 277W peak

CyberPowerPC Infinity Z890 Air

The Core Ultra 7 and RTX 5070 combine to produce stonking rates at 1440p in a high-quality, compact chassis

SCORE ★★★★☆

PRICE £1,583 (£1,900 inc VAT)
from tinyurl.com/368cyberpower

Until this month, my generic if boring advice to anyone specifying a desktop PC was to buy the fastest Nvidia card you could afford. But if you turn to p68 you'll see that AMD has well and truly spoiled the party with its RX 9070 and RX 9070 XT GPUs, all of which means this RTX 5070-powered system must work hard to justify its price.

CyberPowerPC UK, the British arm of the American PC manufacturer, has carefully chosen the supporting components and opted for quality throughout. That starts with the Lian Li Lancool 207 chassis, which is entirely toolless – the tempered glass windows and right-hand side panel even clip in without screws, meaning you simply slip your finger into a groove to remove them.

It's a compact chassis and that inevitably results in space issues when you have a giant MSI graphics card and Be Quiet Dark Rock Pro 5 air cooler crammed inside. Only those with the nimblest digits will be able to insert a PCIe x16 card into the two available slots on the (again top-quality) MSI Pro Z890-S motherboard. You'll need to remove the GPU if you want to fill either of the two spare M.2 sockets, but for now you're well catered for thanks to a 2TB WD Black card that performed brilliantly in CrystalDiskMark 8: 7,127MB/sec reads and 6,632MB/sec writes are almost as good as things can get for a Gen 4 card.

There are two DIMM sockets free, and while those are blocked by the CPU cooler fan, this unclips. The bigger shame is that it blocks your view of the RGB rims on the memory heatsinks. As with storage, there's no need for an immediate upgrade here despite two spare slots: CyberPowerPC supplies a pair of 16GB Kingston Fury Beast DDR5-5600 DIMMs, which proved excellent company for Intel's Core Ultra 7 265KF processor. This 20-core chip likes nothing more than tough multicore tasks, with an excellent 2,029 in Cinebench 2024 and 20,384 in Geekbench 6.

Those are both CPU-exclusive tests, but Nvidia's RTX 5070 comes into play in PCMark 10. An overall score of 9,055 is superb, but I was more drawn to its result of 19,685 in the Digital Creation section. Again, that's exceptional, underlining the fact that this isn't simply a gaming PC despite its trio of RGB fans.

Then again, who's going to spend this much on a PC and not use it for gaming? You can see how the RTX 5070 performs against its peers in our graphs on p69, but during my tests the Infinity Z890 Air proved strongest at 1440p. I tested with *Shadow of the Tomb Raider*, *Dirt 5*, *Borderlands 3* and *Cyberpunk 2077*, with the latter my go-to for ray tracing testing.

Let's start at 1080p and highest/Ultra settings, where the Z890 Air averaged 249fps, 207fps, 147fps and 183fps across the four games. Activating RT Ultra reduced the *Cyberpunk* score to 108fps. When I switched to 1440p those results dropped to 231fps, 163fps, 136fps, 134fps and 89fps (the latter two are *Cyberpunk* at Ultra and then RT Ultra). Even at 4K, results are solid: 151fps, 105fps, 86fps, 66fps and 58fps.

You can upgrade to an RTX 5070 Ti for £150 and RTX 5080 for £483, with commensurate improvements, but if you want 4K gaming for under two grand then this machine is a fine choice. And don't forget that the RTX 50 series supports Multi Frame Generation, raising the prospect of 100+ fps in even demanding AAA games at 4K and top settings (you'll get the best results if/when developers update their games to take advantage of Nvidia's Transformer model).

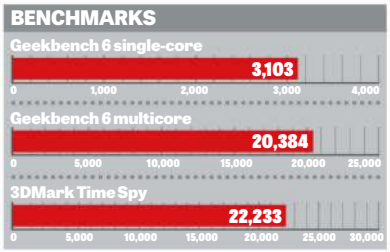
CyberPowerPC sensibly includes an 850W PSU, which meets Nvidia's requirements for the RTX 5080. I measured peak power consumption of 499W so there's clearly plenty of headroom, while 72W at idle is reasonable considering all the cutting-edge components inside. That's reflected in the gentlest of whirrs in general use, reminding me of a babbling brook, which occasionally rose to match more demanding tasks but never hit annoying levels. That's despite two 120mm fans sitting in the base (they're barely visible) that kick into action to ensure strong airflow.

With a warranty that lasts a generous five years – the first year is collect and return, where CyberPowerPC will cover all courier costs, and this and the following year includes parts as well as labour – you can be assured that this money is being well invested for the long term. If this is your budget, it's a great choice. **TIM DANTON**

ABOVE The Infinity Z890 Air is packed with top-quality components

"You can upgrade to an RTX 5070 Ti, but if you want 4K gaming for under two grand then this machine is a fine choice"

BELOW The huge MSI graphics card and Be Quiet air cooler dominate the inside



SPECIFICATIONS

20-core (8 P-cores, 12 E-cores) Intel Core Ultra 7 265KF processor • MSI Pro Z890-S WiFi motherboard • 32GB Kingston Fury Beast RGB DDR5-6000 RAM • 12GB Nvidia GeForce RTX 5070 graphics • Be Quiet Dark Rock Pro 5 air cooler • 2TB WD Black SN7100 PCIe Gen 4 SSD • Lian Li Lancool 207 chassis • 850W Corsair RM850X PSU • Windows 11 Home • 219 x 456 x 456mm (WDH) • 5yr warranty (1yr C&R, 2yr parts) • power: 72W idle, 499W peak

Lenovo ThinkCentre M70q Gen 5 Tiny

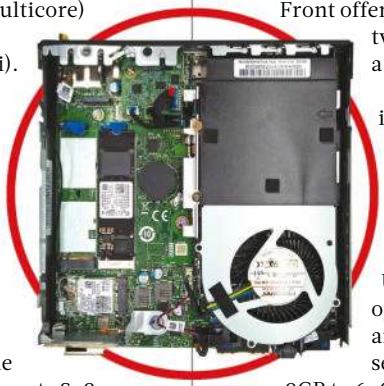
This sturdy, easily configured mini PC offers plenty of adaptability, adding to its appeal for office rollouts

SCORE ★★★★☆

PRICE As reviewed, £923 (£1,107 inc VAT)
from lenovo.com

There's no messing around here: the fifth generation of the ThinkCentre M70q will only be of interest to business buyers. While you can buy it in single units, it feels destined for large-scale rollouts – perhaps to individual homes, as IT teams can manage these PCs remotely if you choose the versions with vPro chips.

For this is the Intel version of the M70q Gen 5, with CPU choices ranging from the non-vPro Core i5-14400T to the Core i7-14700T vPro, with a price difference of £300 between those two extremes. The "T" suffix indicates this range's leaning towards power efficiency, but my test unit with a Core i7-14700T and 16GB of RAM showed rapid pace in Geekbench 6 (2,686 single core, 12,755 multicore) and Cinebench 2024 (118 single, 959 multi). Its weakness is 3D acceleration, as illustrated by a 905 return in 3DMark Time Spy and 15fps in *Dirt 5* at 1080p Low settings.



LEFT There's space for a second M.2 SSD in the compact chassis

This is also a versatile chassis, equally at home behind a monitor (the VESA mounting unit costs £28 extra), on an arm or on a desk, where it can sit sideways or horizontally. In terms of footprint, think 7in vinyl single. It won't take up much space, and most of the time you'll forget its existence, such is the quietness of its fans; the only time they became noticeable was during intense benchmarks. At this point, its power consumption jumped from 14W idle to a 129W peak, so it's little wonder you hear fan noise. It's also why it needs an external power brick and can't be powered over USB-C.

At roughly an inch tall there's room inside for a 2.5in drive if you can source a caddy (Lenovo doesn't offer one during configuration), but it's unlikely you'll need it as there's space for a second M.2 SSD next to the supplied unit. You can add a second drive later or configure at the time of purchase. Other internal customer replaceable units include the speaker, system fan, coin-cell battery and M.2 Wi-Fi card. A trained technician could access the two SODIMM sockets, but these are hidden under the heatsink fan.

But what really makes this mini PC special is the amount of configurability available at the time of purchase. My unit had a USB-C port in one of the two expansion ports, but you can choose HDMI, VGA, DisplayPort and serial connectors, too. These supplement the default offerings of four USB-A ports, 1Gb Ethernet, HDMI and DisplayPort (there's also a single aerial socket and the power input).

Front offerings are limited to two USB-A ports and a USB-C port.

The price above includes Windows 11 Pro, but you can save £60 if you downgrade to Windows 11 Home, £85 by switching to Ubuntu and £110 by opting not to include an OS. Memory setups range from 8GB to 64GB, all DDR5-4800, and you can opt for a second Ethernet port and an upgrade to Wi-Fi 6E. For such a tiny PC, it really does offer an incredible number of options.

This diminutive thing can cope with the toughest environments, too. It has met 12 of the MIL-STD 810H standards, and if you buy the dust filter it can cope with desert storms to go along with extreme temperatures, not to mention high humidity and pressure. Still, you may want to upgrade the three-year on-site warranty to "Premier Onsite Support", which upgrades this to next-business-day cover (with the usual caveats on location and part availability) for £84.

ABOVE The diminutive ThinkCentre M70q is perfect for large-scale business rollouts

"What really makes this mini PC special is the amount of configurability available at the time of purchase"

You don't need to decide at the time of purchase. Load up Lenovo's Commercial Vantage software and you can view how long is left on your current warranty and what your upgrade options are. This is also the place to visit for system updates and troubleshooting, and if you need to support remote workers it's an easy way to perform hardware checks.

Bearing in mind you can configure the base level ThinkCentre M70q Gen 5 for £774 inc VAT (including Windows 11 Pro), it's hard to argue with the value here. Sure, consumer-targeted mini PCs such as the £499 inc VAT Geekom A6 I reviewed last month are cheaper, but there's a gulf between Lenovo and Geekom when it comes to the type of support businesses need.

So I go back to my first point: this is a mini PC that only businesses need consider. Whether for performance per-pound, per-watt or per-square-inch, it meets its target buyers' demands perfectly. **TIM DANTON**

SPECIFICATIONS

20-core (8 P-cores, 12 E-cores) Intel Core i7-14700T vPro processor • 16GB DDR5-4800 RAM • Intel UHD graphics • 256GB M.2 NVMe PCIe Gen 4 SSD • Wi-Fi 6E • Bluetooth 5.3 • 1GbE port • HDMI 2.1 • 2 x USB-C 3.2 Gen 1 • 4 x USB-A 3.2 Gen 2 • USB-A 3.2 Gen 1 • USB-A 2 • 3.5mm combo jack • 179 x 183 x 36.5mm (WDH) • 1.3kg • Windows 11 Pro • 3yr on-site warranty

BELOW Add ports of your choice into the two expansion slots

How we test

Laptops and PCs

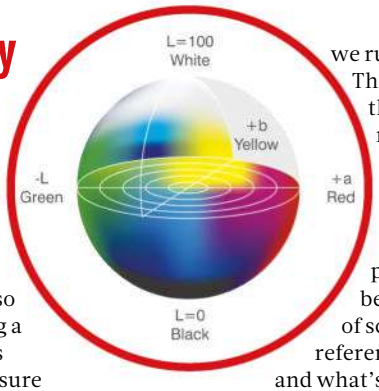
We run a selection of benchmarks on all the PCs and laptops we test. Where possible, we use a cross-platform test so we can compare Windows and macOS machines, which is where both Geekbench and Cinebench come into play. Both push the CPU to its limit, exposing how well cooled a system is.

We run extra tests for Windows systems. We use PCMark 10 to benchmark systems in office tasks, content creation and basic tasks such as web browsing and video calls. We also run 3DMark Time Spy and *Shadow of the Tomb Raider* as a minimum. We test laptops and PCs that include discrete graphics with a range of games, such as *Metro Exodus Enhanced* and *Dirt 5*.

For laptops, we test battery life with Wi-Fi on and the screen brightness set to 150cd/m². We fully charge the laptops and drain them until they reach 5%. For Windows laptops, we will use a mix of PCMark 10's light-use and video-based tests, or a web surfing benchmark where a laptop automatically visits sites until the battery dies. We also use this test for MacBooks.

ABOVE We put PCs and laptops through our intensive set of benchmarks

Screen quality



In each laptop, phone, tablet and monitor review, you'll see our conclusions about the screen quality. Some of this will be subjective, but we also test each screen using a X-Rite Display i1 Plus colorimeter. We measure maximum brightness, colour accuracy and (for monitors) consistency – there may be a difference in, say, brightness from the middle and the edges of the panel.

We also measure Delta E, which is a guide to how accurately panels display colours. Anything under 1 is excellent and likely to be difficult for the human eye to distinguish; between one and two is still strong; above this suggests a panel that you shouldn't trust for colour-accurate photo editing.

LEFT We use a Display i1 colorimeter to measure sRGB gamut coverage and Delta E

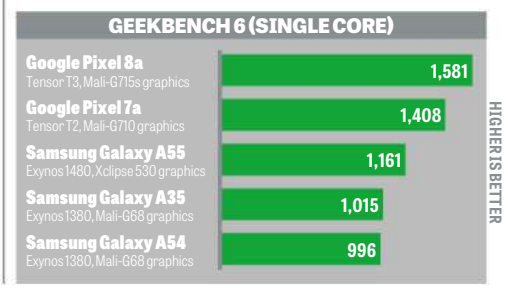
Phones and tablets

We run a selection of publicly available benchmarks on all the phones and tablets we review. First, we run Geekbench 6. This is a good test of the processor and memory in particular, and include both a test for single-core and multicore performance. See below for a selection of scores to provide a reference of what's good... and what's not so good.

We also run 3DMark Wild Life test to give a measure of gaming performance.

We test tablet battery life by playing a full-screen video until the battery runs out with the device. To simplify the test, we use Airplane mode. We set the brightness to as close to 150cd/m² as we can get in the device's settings. We also put phones through a set of real-world and labs-based tests.

BELOW We play a video with the screen set to 150cd/m² to test battery life



What our awards mean

Recommended
This, quite simply, is a product we recommend you buy – if it meets your needs.

A-List
The best buy in its category right now. The product will also feature on our A-List, starting on p14. It's updated each month.

Labs Winner
Each month we run a group test, or Labs. This product has managed to beat all others to top position.

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Prices will vary

Prices we publish are correct on the day we publish, but we often see prices change, especially on sites such as Amazon. However, we do work with British PC retailers to ensure the prices we quote for their systems are correct. If the price isn't being honoured, contact us via letters@pcpro.co.uk.

AMD Ryzen 9 9950X3D

Simply the best processor around thanks to its fantastic performance in games and demanding tasks

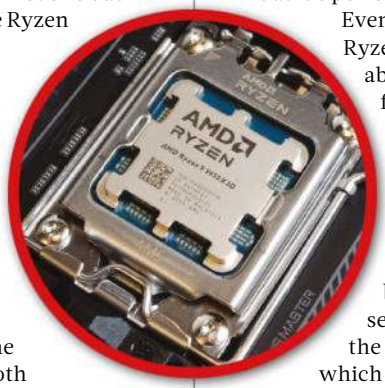
SCORE ★★★★★

PRICE £583 (£700 inc VAT)
from scan.co.uk

AMD's Ryzen 9 9950X3D is something special. It's the company's latest "flagship" chip, and I'm comfortable saying that it's the best processor ever made for the consumer market.

For sure, that comes at a price. As well as being the greatest mainstream CPU, it's also the most expensive at £700 inc VAT. By comparison, Intel's current top-ranking chip, the Core Ultra 9 285K, seems positively affordable at only £572. Then again, the new AMD processor will work in any AM5 motherboard, while Intel's offering requires a whole new chipset.

The best way to understand what's so special about the Ryzen 9 9950X3D is to compare it to its predecessor. This means stepping back not one but two generations: the Ryzen 8000 series didn't include any Ryzen 9 processors, so this chip replaces the Ryzen 9 7950X3D, released back at the start of 2023.



On paper there's not much difference between that 7000-series processor and the one before us. They're both made on a 4nm process, and they each feature 16 physical CPU cores, with AMD's SMT technology serving 32 threads at once. Clock speeds are more or less identical, with both models boosting up to a maximum of 5.7GHz when needed. And as the "X3D" suffix indicates, the two chips each feature a generous 128MB of L3 cache – a feature dubbed "3D V-Cache" by AMD, as the extra cache memory is physically stacked on top of the standard allocation.

At the same time, there are a few key architectural differences. For one, the Ryzen 9 9950X3D uses AMD's latest Zen 5 core, which has several inherent performance advantages over Zen 4. Perhaps more significantly, the 3D cache in the 9950X3D has been moved to sit beneath the processor die, rather than on top of it as in previous models. This means the CPU cores are now located directly below the lid of the chip, right next to the heatsink; consequently, the Ryzen 9 9950X3D can run faster for longer than the 7950X3D without the risk of overheating.

What's more, it's fully unlocked, so you can overclock it to wring out even more performance, which wasn't possible with the multiplier-locked 7950X3D. A TDP of 170W demands a high-performance cooling solution, but it's perfectly manageable.

Even at stock speeds the Ryzen 9 9950X3D is an absolute powerhouse for general computing. In Geekbench 6 benchmark it achieved a single-core score of 3,261 – one of the best results we've seen, matched only by the Ryzen 9 9950X, which is the same chip without the extra 3D V-Cache.

This makes the Ryzen 9 9950X3D around 15% faster than the old Ryzen 9 7950X3D for single-threaded tasks, and impressively around 12% faster than Intel's top-of-the-range Core Ultra 9 285K. The Ryzen chip didn't quite beat the Core Ultra 9 in the multicore test, but its score of 20,139 was within 5% of its Intel rival, so overall we'd call AMD the winner.

Since the Ryzen X3D line is aimed primarily at gamers, I also tested the Ryzen 9 9950X3D in a range of games, and was again very happy with what I saw. For example, in *Cyberpunk 2077* the new AMD chip stood head and shoulders above the competition, achieving an average frame rate of 331fps at 1080p while the Intel Core Ultra 9 only managed 254fps.

The chip stumbled only once. In the *Total War: Warhammer III Mirrors of Madness* benchmark the Ryzen 9 averaged a respectable 258fps, but lagged well behind the 317fps of the Intel chip.

To understand the likely reason for this, you need to know that the 9950X3D's 16 cores are internally divided into two complexes of eight cores each – and that only one of these complexes has access to the extended 3D V-Cache. These results strongly suggest that the main code for the *Total War* benchmark was running on the wrong complex, and therefore couldn't take advantage of the extra cache.

That's all but confirmed by the fact that I saw effectively identical frame rates from the Ryzen 9 9950X, which only has the smaller 64MB of L3 cache. Meanwhile, the eight-core Ryzen 7 9800X3D did much better: its single-complex design meant that every core was guaranteed to have access to the V-Cache, and the result was a far superior score of 413fps.

This may well be an early-adopter blip. AMD's chipset drivers are supposed to intelligently divide up the workload to ensure that processes that can benefit from the V-Cache can access it, so hopefully an update will come along in the near future that fixes performance in this game, and perhaps in other titles, too.

Even so, depending on your priorities you might consider the Ryzen 7 9800X3D as a possible alternative. While its multicore capabilities aren't as extravagant, it's still one heck of a chip – and you'll get a guaranteed performance boost in both games and desktop apps, almost regardless of what you're upgrading from. You'll also save a good chunk of money, as it sells for around £490 inc VAT.

There's no disputing the Ryzen 9 9950X3D is the best all-round processor on the market. It offers exceptional performance in just about every test, and there's scope to go way higher with suitable cooling. Sure, it's expensive, but for the enthusiast market it's aimed at that's almost a non-issue – perhaps even a badge of honour. **JOHN LOEFFLER**

ABOVE **The Ryzen 9 9950X3D is the best all-round processor on the market**

PC PRO RECOMMENDED

"It offers exceptional performance in just about every test, and there's scope to go way higher with suitable cooling"

LEFT **The CPU cores are now directly below the lid of the chip, next to the heatsink**

BELOW **The chip has a few key architectural differences to its predecessors**

SPECIFICATIONS

16 cores • 32 threads • 4.3GHz base frequency • 5.7GHz max boost frequency • 128MB Level 3 cache • supports up to DDR5-5600 RAM • AM5 socket • 170W TDP

QNAP

12-bay High-speed All Flash NAS

TS-h1277AFX

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25 GbE

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Norton Mobile Security 2025

- One-device, one-year licence worth £30
- uk.norton.com

REQUIRES Android 10 or later; iOS/iPadOS 16 or later; online registration

Smartphones and tablets are treasure troves of personal information. From lists of contacts to credit and debit card details, your email inbox, personal notes and the data in your favourite apps, your mobile devices are loaded with private information about you, your contacts and your family. And malicious actors would love to get their hands on it – which is why it's not just desktop PCs and laptops that need protection from malware and other types of cyber-attack.

The breadth of protection is important, because many of today's threats exploit human nature, and try to trick us into responding to risky text messages, opening malware-laden emails, visiting fake websites, and more. It can only take a moment of distraction on your part to fall into their trap – and then it's too late.

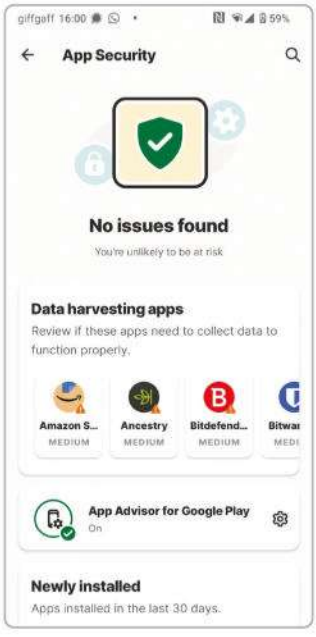
Norton Mobile Security provides an essential defence against these and other threats to your Android or iOS-powered phone or tablet. Think of it as a safety advisor watching over your shoulder as you use your mobile device.

Once installed and activated, it offers real-time protection against known threats, backed up by a smart scan that examines your system to make sure your device is up to date and immune to known vulnerabilities. It will also highlight any risky or untrusted apps you may have installed.

You'll benefit from Norton Safe Web protection, too, which scans SMS messages, websites, search results and apps for potentially dodgy links and unsafe websites. And a built-in Wi-Fi scanner vets any connected network to make sure it's safe and properly secured.

You can review all of these tools from the app's Menu section, and we would recommend tapping each one in turn to get a summary of your device's current security status. You'll also find extra features such as screening incoming SMS messages from unknown contacts and proactively protecting against risky Wi-Fi networks; to enable these, follow the simple instructions to grant Norton Mobile Security the required access to your system.

This month, we're giving every reader a one-device, one-year subscription to Mobile Security 2025 for Android, iPhone or iPad. This also includes Norton Password Manager, combining a local app with an online vault for generating and storing sensitive information, such as login details and other credentials.



ABOVE The suite can check your installed apps and offer advice on how to keep your data safe

Wi-Fi Security
Connected to secure network
This network is password protected and has strong encryption.
Network name:
Oh_Canada
Set up real-time protection
To scan for all possible Wi-Fi threats, please allow Norton 360 to access:
Location permission
Select "All the time"

ABOVE Wi-Fi Security ensures the network you're connected to has adequate security measures

ABOVE Norton Mobile Security takes a comprehensive approach to protecting your device and data from criminals

Ashampoo Photo Optimizer 10

- Easy-to-use tool for tuning and fixing your digital images with an app-like approach to photo tweaking
- No complicated interface needed: just select your photos and apply your desired effects in a click or two
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Full product worth £35 ashampoo.com
REQUIRES Windows 10 or later; 150MB drive space; online registration

Abelssoft GClean 2024

- Reveal data and cookies set by Google products, including Maps, Gmail, YouTube and Chrome
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Full product worth £10 abelssoft.de
REQUIRES Windows 8 or later; 50MB drive space; online registration

Audials One 2025

Full product worth £30 audials.com
REQUIRES Windows 10 or later; 1GB drive space; online registration

- A one-stop-shop for streaming: listen to music and podcasts, or watch online TV and movies
- Search for your favourite songs, download tracks and make them available offline
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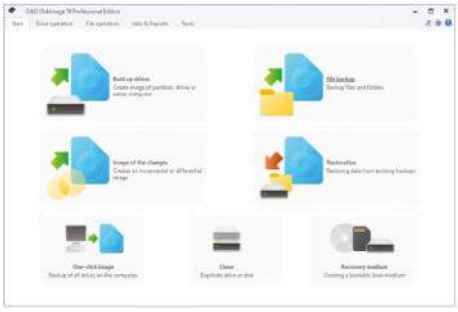

Full product worth £36 oo-software.com
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- Archives can be mounted like external drives in Windows for easy data restoration

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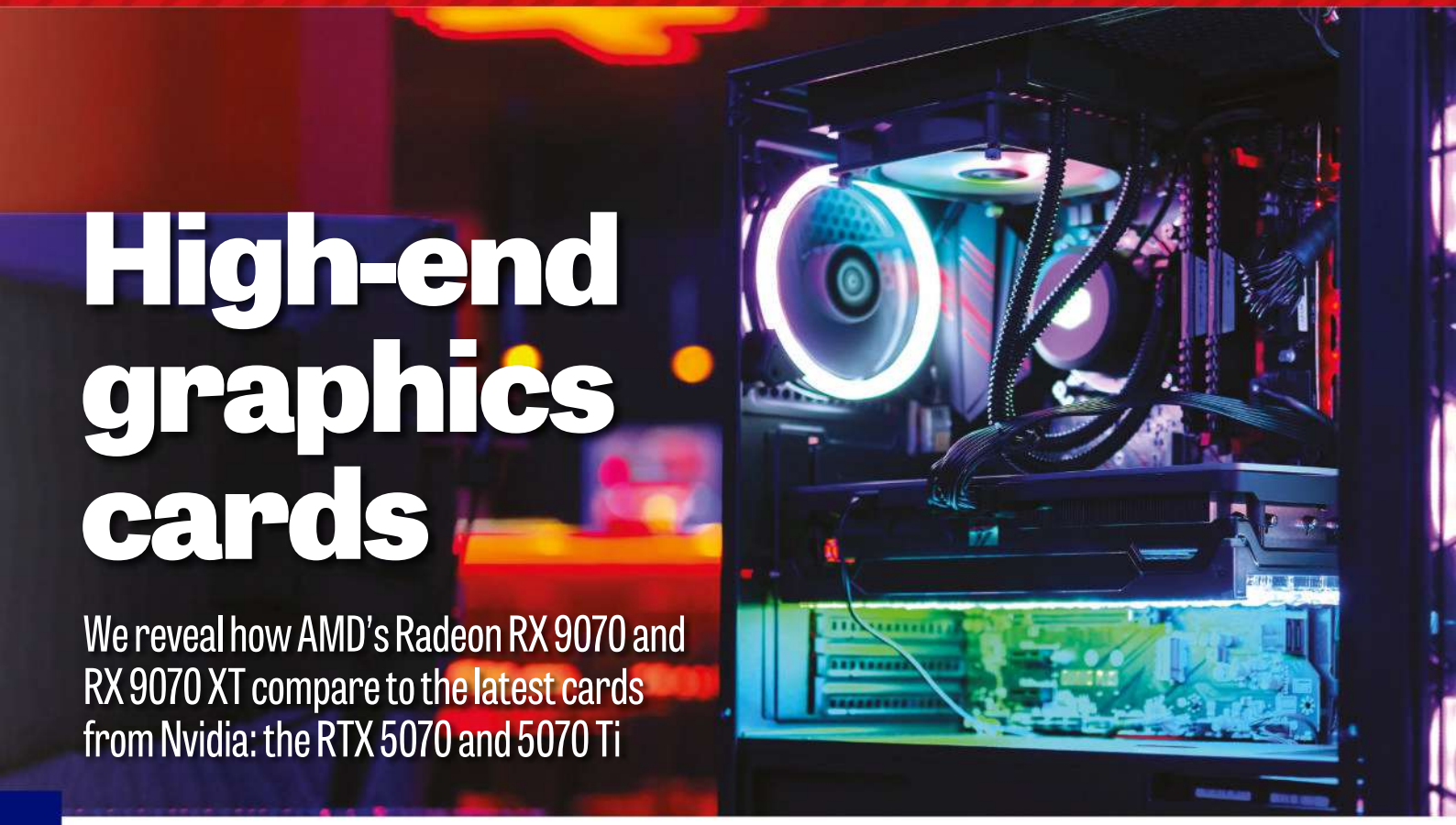


High-end graphics cards

We reveal how AMD's Radeon RX 9070 and RX 9070 XT compare to the latest cards from Nvidia: the RTX 5070 and 5070 Ti

AMD had one job to do with the launch of its RDNA 4 graphics cards – spearheaded by the Radeon RX 9070 and RX 9070 XT – and that was to not get run over by Nvidia's Blackwell too badly this generation.

With the RX 9070 XT in particular, not only does AMD hold its own against the GeForce RTX monolith, it perfectly positions Team Red to take advantage of the discontent among gamers upset over the price and availability of Nvidia's latest GPUs. Not just the RTX 5080 and 5090 we reviewed last month (*see issue 367, p46*), but also the newly released RTX 5070 and RTX 5070 Ti.

We expect Nvidia to launch the RTX 5060 and 5060 Ti in the coming weeks, but for now we must content ourselves with comparing the four cards that might be called "high end". And close to the top: as we'll see, the Radeon RX 9070 XT comes very close to the GeForce RTX 4080 in 4K and 1440p gaming performance.

AMD's RDNA 4 cards

Last month we went into detail on Nvidia's Blackwell architecture, so we'll focus here on AMD's RDNA 4.

It's built on TSMC's N4P node, the same as Nvidia Blackwell, and in a move away from AMD's multi-chip module (MCM) push with the last generation, the RDNA 4 GPU is a monolithic die. You can see how the Navi 48 GPU in the RX 9070 and RX 9070 XT compares with the RTX 5070 and RTX 5070 Ti cards in the table below, but there's no shortage of silicon. For instance, the RX 9070 XT sports 64 compute units, breaking down into 64 ray accelerators, 128 AI accelerators and 64MB of L3 cache. Its cores are clocked at 1,600MHz to start, but can run as fast as 2,970MHz.

There are three areas where AMD falls behind Nvidia on paper. First, its cards must make do with roughly half the number of shaders, but they work in different ways so aren't directly comparable. Second, Nvidia wins for AI/matrix cores. And third, AMD uses the same GDDR6 memory as the previous-gen AMD cards. However, with a 256-bit bus and 645GB/sec bandwidth there's more than enough to push out 4K frames quickly.

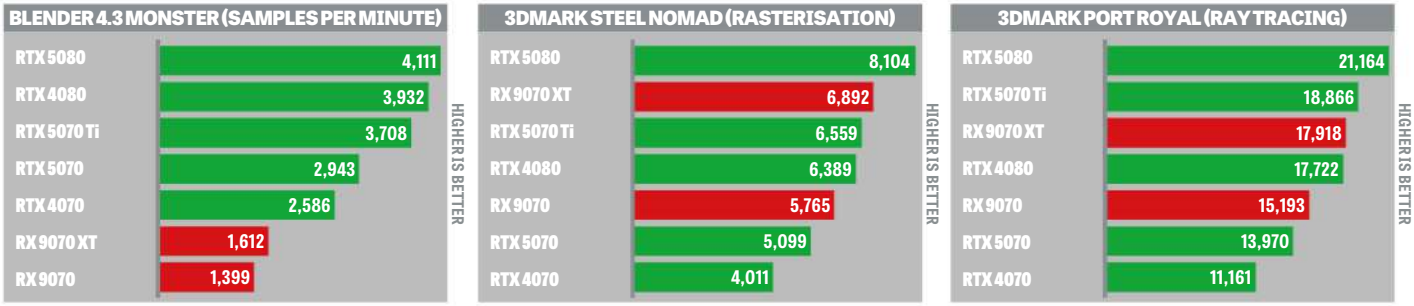
Power struggle

The 304W TGP of the RX 9070 XT all but ensures that any version of this card (there's no reference card) will be a triple-fan cooler over a hefty heatsink, so it's not going to be a great

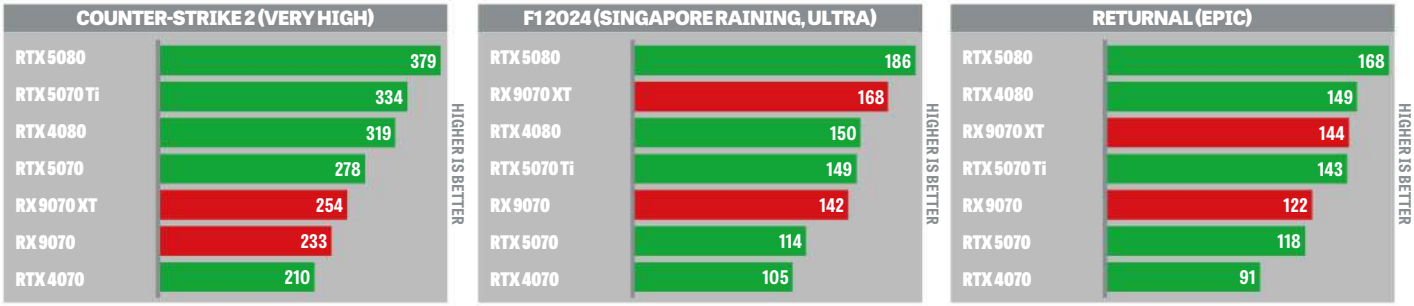
FEATURE COMPARISON TABLE

	Nvidia RTX 5080	Nvidia RTX 5070 Ti	Nvidia RTX 5070	AMD RX 9070 XT	AMD RX 9070
Price at launch	£979	£729	£539	£570	£525
Process technology	TSMC 4nm	TSMC 4nm	TSMC 4nm	TSMC 4nm	TSMC 4nm
Architecture	Blackwell	Blackwell	Blackwell	RDNA 4	RDNA 4
Transistors (billion)	45.6	45.6	31.1	53.9	53.9
Compute units	84	70	48	64	56
Shaders	10,752	8,960	6,144	4,096	3,584
AI/matrix cores	336	280	152	128	112
Ray tracing cores	84	70	48	64	56
Render output units	128	112	64	128	128
Texture mapping units	336	280	192	256	224
Boost clock (MHz)	2,167	2,452	2,512	2,970	2,520
Memory type	GDDR7	GDDR7	GDDR7	GDDR6	GDDR6
VRAM (GB)	16	16	12	16	16
VRAM bus width	256	256	192	256	256
VRAM speed (Gbits/sec)	30	28	28	20	20
Bandwidth (GB/sec)	960	896	672	645	645
TDP (watts)	360	300	250	304	220
PCIe interface	PCIe 5.0 x16	PCIe 5.0 x16	PCIe 5.0 x16	PCIe 5.0 x16	PCIe 5.0 x16

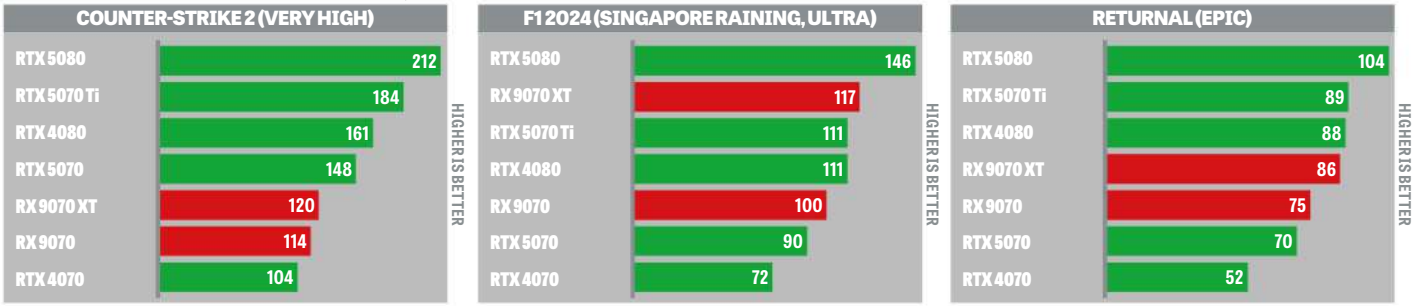
PROFESSIONAL & SYNTHETIC BENCHMARKS



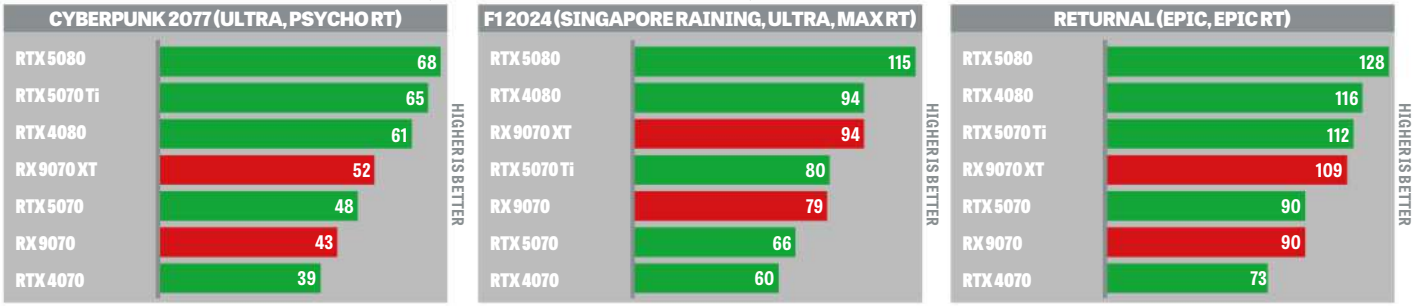
1440P GAMING (NO RAY TRACING, AVERAGE FPS)



4K GAMING (NO RAY TRACING, AVERAGE FPS)



4K GAMING (MAX RAY TRACING, BALANCED UPSCALING, FPS)



The test rig used an Intel Core i9-14900K on Windows 11 24H2.

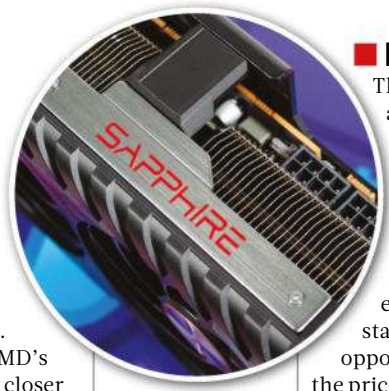
option for small form factor cases. That TGP means it needs a third 8-pin PCIe power connector, unlike the RX 9070, which has an impact on cable management. In terms of outputs, two HDMI ports sit side by side with a pair of DisplayPort 2.1a connectors. Likewise for the RX 9070.

Your chosen RTX 5070 Ti is likely to be a chunky card, too, as Nvidia isn't releasing a Founders Edition version with its dual pass-through design. That likely means a triple-fan design plus a 16-pin power connector. The good news for RTX 5070 buyers is that there is a Founders Edition version and it easily fits inside a small form factor case, while its lighter power draw is yet another plus.

On your marks

So to the question: which is fastest? The RTX 5070 Ti wins without question, with the bonus that it can draw upon Multi Frame Generation (MFG), as can the RTX 5070, to push frame rates even higher than you see above. At 4K, nearly every title I tested hit 60fps or greater on average.

But the great news is that AMD's RX 9070 XT pushes the 5070 Ti closer than expected. At 4K, it averaged 82fps compared to 89fps for the RTX 5070 Ti, 85fps for the RTX 4080 and 71fps for the RX 9070. It also held its own in ray tracing tests. It was only creative benchmarks where AMD struggled.



ABOVE AMD's RX 9070 XT pushed Nvidia's finest close in our benchmarks

Feast or famine

There's one big problem facing any buyer of high-end graphics cards right now: price and availability. Too many companies are in the queue for TSMC's processes. That's driving up prices to the point where MSRPs are effectively meaningless; the starting prices in the table opposite bear little resemblance to the prices you will actually pay.

All of which means that the wise buyer should either shop around or, more sensibly perhaps, wait. With that caveat, turn the page for short reviews of all four cards. **JOHN LOEFFLER**

AMD Radeon RX 9070

SCORE ★★★★☆

PRICE From £496 (£595 inc VAT) from scan.co.uk

If AMD's MSRPs were to be believed, there would be little point considering the RX 9070. This card doesn't have enough firepower to deliver consistent rates over 60fps at 4K, whereas its XT variant does. Eith the latter only costing an extra £50, it would be the very definition of a no-brainer decision.

In reality, you can buy variants of this card (there is no reference version to match Nvidia's Founders Edition) for a little under £600, while the RX 9070 XT cards now start at around £670, often pushing over £700. That means you should engage your brain, as there is an argument for this as a 4K card.

It very much depends on which games you're going to be playing: we saw the RX 9070 deliver 128fps in *Civilization VII* on max settings, with *Dying Light* at 79fps. But switch to tougher games such as *Cyberpunk 2077* at Ultra settings and it managed 53fps, while the XT averaged 61fps.

If you're going to be playing at 1440p then the difference between the two cards – roughly 15% – becomes less impactful. Here, all the cards on test month easily exceeded 100fps in almost all our tests.

The RX 9070 (and the RX 9070 XT) look less compelling in creative tasks. Averaging our scores, the RX 9070 was around 30% slower than the RTX 5070 here. So long as your priority is gaming, then, the RX 9070 is a solid choice.

AMD Radeon RX 9070 RT

PC PRO RECOMMENDED

SCORE ★★★★☆

PRICE From £558 (£670 inc VAT) from scan.co.uk

This, dear Nvidia, is how to launch a new generation of graphics cards. No wild promises, just power: AMD's Radeon RX 9070 XT delivers RTX 4080-levels of gaming performance at half the price. Its strengths lie in raw gaming performance. At 1440p, it holds its own against Nvidia's heavy hitters: about 8% faster than the RTX 4070 Ti, 4% slower than the RTX 4080 and 7% slower than the RTX 5070 Ti. This carries over into 4K gaming, thanks to the RX 9070 XT's 16GB VRAM. Here, it's about 15% faster than the 4070 Ti, 2.5% quicker than the RX 7900 XTX and a mere 3.5% slower than the RTX 4080. It also comes within 8% of the RTX 5070 Ti's 4K performance.

The RX 9070 XT excels at rasterisation workloads, while the RTX 5070 Ti edges ahead in ray-traced workloads. However, AMD's third-gen ray accelerators have come a long way in catching up with Nvidia's more sophisticated hardware. When it comes to creative workloads, the RX 9070 XT performs well in raster-based tasks such as photo editing, and worse at 3D modelling in Blender, which is heavily reliant on Nvidia's CUDA instruction set.

AMD's flagship card doesn't quite overpower the RTX 4080 and falls short of the RTX 5070 Ti, but given its price, power draw and low heat output, the RX 9070 XT is easily the best value of any graphics card playing at 4K.

Nvidia RTX 5070

SCORE ★★★☆☆

PRICE From £499 (£599 inc VAT) from scan.co.uk

Nvidia made the classic mistake of overpromising and underdelivering with the RTX 5070. The gulf between what was expected from Jensen Heung's speech at CES 2025 and what the RTX 5070 actually delivers is simply too wide a gap to bridge for gamers and enthusiasts. In short, not enough speed, not enough supply and the price is too high.

The "broken promise" was RTX 4090 levels of speed. It wasn't exactly a lie: the RTX 5070 does reach native RTX 4090 performance in some games thanks to Blackwell's Multi Frame Generation (MFG) technology. And, to be fair, the RTX 5070 is a substantial improvement over the RTX 4070, with a roughly 20-25% performance gain. The challenge for Nvidia is that the RTX 5070 barely outpaces the RTX 4070 Super when you take MFG off the table, and that will be the case for most games played on this card. From that point of view, you don't have anything to show for the extra 30W of power this card pulls down compared to the RTX 4070 Super. And the older card can still be found for around £475.

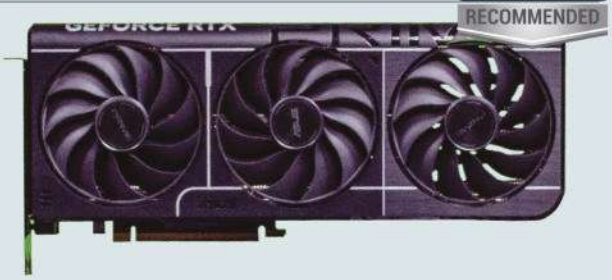
The 5070 faces newer competition in the form of the RX 9070, and here it's nip and tuck depending on the game. Overall, AMD's card is 1fps slower at 1440p and 2fps faster at 4K. Where the RTX 5070 clearly wins is in creative tasks, but that is to be expected due to CUDA's domination.

Nvidia RTX 5070 Ti

PC PRO RECOMMENDED

SCORE ★★★★★

PRICE From £716 (£860 inc VAT) from scan.co.uk



Forget the RTX 5080: if you're a gaming enthusiast or graphics/video creator and don't fancy spending over a grand on a GPU, the 5070 Ti is the card to buy. It stands out due to its significant uplift compared to the RTX 4070 Ti and RTX 4070 Ti Super, even rivalling the RTX 4080 Super in certain tasks. Look at the graphs on the previous page and you'll see that it's also consistently ahead of the RX 9070 XT in games, while demolishing it in creative tasks.

Starting with 1440p gaming, the gen-on-gen improvement of the RTX 5070 Ti over the RTX 4070 Ti is a solid 20%, even without factoring in DLSS 4 with MFG. And it's excels at ray tracing: the RTX 5070 Ti's *minimum* fps exceeded 60fps (often by a lot) for all but one of the games I tested at 1440p.

For 4K gaming, native performance is spectacular, with almost every title tested hitting 60fps or more. In fact, the average 4K performance for the RTX 5070 Ti is pretty much dead even with the RTX 4080 Super's performance.

In creative workloads such as Blender Benchmark 4.30, the RTX 5070 Ti pulls way ahead of its predecessors, edging close to RTX 4080 levels. The three questions before you buy are price (you only have third-party designs to choose from, with no Founders Edition), power demands (it will need a 750W PSU) and whether the cheaper RX 9070 RT is fast enough for your needs.

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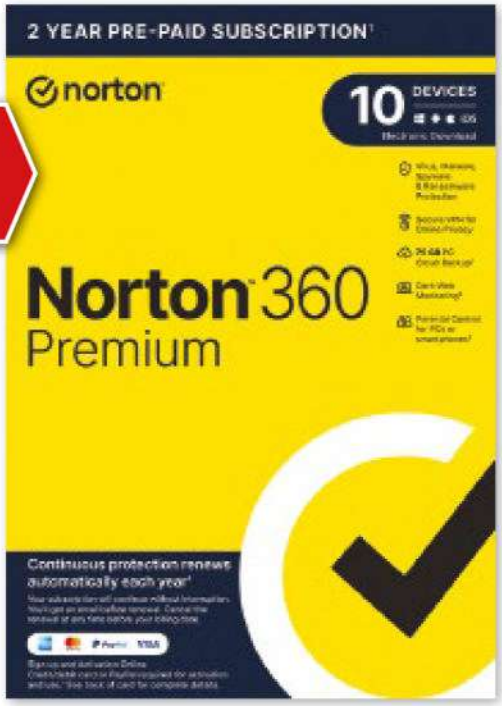

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And because it's the Premium version, you get a host of extra tools. There's 75GB of cloud storage for secure backups, plus the full version of Norton Secure VPN, both to protect your identity and provide a way of watching British TV while you're abroad.

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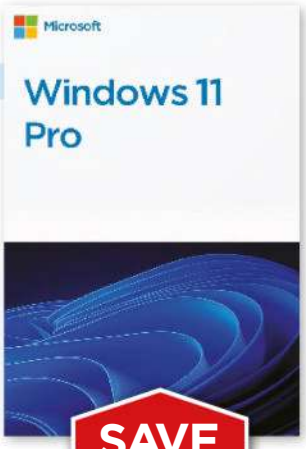

Want to upgrade from Windows 11 Home to Windows 11 Pro? Or perhaps you're looking to move up from Windows 10 Home?

Whatever your motives, a Windows 11 Pro upgrade licence is a great choice. The first reason is simple: price. Microsoft charges £119.99 for a retail licence of Windows 11 Home, a staggering £219.99 for Windows 11 Pro, and £119.99 for its own upgrade licence from 11 Home to Pro. By choosing this licence – and avoiding the many dubious sources of licences you may find online – you cut that price substantially.

Unlike Windows 11 Home, Windows 11 Pro enables you to connect to a business domain. It also provides BitLocker to encrypt whole drives. Best of all, you can create and host virtual machines using Hyper-V, which is ideal for testing new software or, if you're a developer, seeing how your software performs on a fresh OS.

Note that the upgrade only works from an activated copy of Windows 11 Home, so if you're currently using a Windows 10 Home system then you'll need to upgrade from that to Windows 11 Home before this upgrade can work.

Want to upgrade from Windows 7 or 8? Or building a PC from scratch? Then head to **tinyurl.com/windowspro11** and grab a full 1-PC licence for Windows 11 Pro for only £79.99.

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Not only does Norton Utilities pack several components, it also offers more than one way to use them. For people who don't want to get too involved, there are one-click options for quick results. But you can also work through all of the recommendations the software offers after analysing your computer.

The Dashboard provides a handy overview of your system, complete with explanations for any detected issues. This can range from problems in the Registry and junk files wasting space to unnecessary startup programs increasing boot times and slowing down your computer. Click the "Repair All" button to apply all of the recommendations, or spend time checking which you would like to use.

Then there's the Norton Utilities Toolbox, which includes five individual cleanup tools: all-in-one cleanup, internet cleanup, Windows cleanup, Registry cleanup and an advanced uninstaller.

Norton provides yet more tools in the self-explanatory Speed Up section, including a memory optimiser, startup time reducer and defragmenter. The Protect section is home to privacy-related tools such as a secure file shredder, while the Recover section is there to help fix problems.

There's one final problem Norton can help you with: cost. Your one-year licence costs £10 – a £19.99 saving over the full price – and allows you to boost the performance of up to ten computers.

Apple iPhone 16e

The cheapest iPhone sure ain't cheap, but this is a huge upgrade over the iPhone SE 2022

SCORE ★★★★☆

PRICE 128GB, £499 (£599 inc VAT)
from apple.com/uk

ABOVE The iPhone 16e looks almost identical to the full-fat iPhone 16

Originally released in 2016, the iPhone SE was an attractive alternative to Apple's shiniest handsets – a low-cost option whose design and update schedule were decoupled from the main iPhone line. Now, though, it's been discontinued, in favour of a new approach: as the name implies, the iPhone 16e is a close relative of the regular iPhone 16, and I suspect it will be updated annually along with the rest of the family.

The pricing strategy has changed, too. The last iPhone SE, released in 2022 (*see issue 332, p70*), cost a deliciously affordable £419 inc VAT, but the 16e starts at £599 inc VAT with 128GB of storage – only £200 less than the standard iPhone 16. There are also 256GB and 512GB options costing £699 and £899 respectively, pushing you well outside "budget" territory.

Solid start

The iPhone 16e may be pricier than the iPhone SE 2022, but it looks much nicer too. The matte aluminium frame is solidly constructed and not as fragile as the glass-covered SE, and it does a fine job of repelling fingerprints and smudges. The casing is shorter and lighter than the iPhone 16, but it has the same flat edge and the same IP68 rating (indicating excellent resistance to dust and water intrusion).

Indeed, with its USB-C port and Action button you could easily mistake this phone for the full-price model. The main visible differences are a wider notch in the display and the single rear camera. The 16e is only available in black or white, but Apple may introduce other colour options at some point, as it did with the SE.

Screen hertz

The iPhone 16e has a 6.1in OLED display that's much bigger and better than the 4.7in IPS screen of the old iPhone SE. In fact, it is – surprise, surprise – very similar to the one on the full iPhone, with striking colours and wide viewing angles. Remember that both phones are limited to a 60Hz refresh rate, though, rather than the smooth 120Hz of the Pro models.

Apple doesn't hold back on candelas, with a peak brightness of 1,028cd/m². This makes it much easier to view outdoors than the iPhone SE 2022, which we measured at around 600cd/m². I pulled up a 4K HDR video on both phones and the difference was impossible to miss: the iPhone 16e display was brighter, more vibrant and generally more engaging.

Another change from the SE is that the 16e uses Face ID rather than the old Touch ID authentication. It's handy to glance quickly at the phone to unlock it, but every time I do so I notice the iPhone 16e doesn't have a "Dynamic Island" – just a static notch for the camera. If you're not used to the Dynamic Island you won't miss it, but it's one way in which the iPhone 16 feels more upmarket.

BELOW There's even an Action button on the side, just like its more expensive sibling

Snap chat

The most visible difference between the iPhone 16e and the regular phone is the single rear camera. This represents an unusual degree of stripping down: Android rivals such as the Google Pixel 8a (*see issue 358, p74*) pair a main camera with an ultrawide lens, while the OnePlus 13R (*see issue 366, p74*)

and Samsung Galaxy S24 FE (*see issue 363, p76*) also throw in a dedicated telephoto camera for a similar price.

What it lacks in versatility, the iPhone 16e's camera makes up for in quality. When I compared a sample beach shot to the same scene captured on the Pixel 8a, I far preferred the brighter, bolder pic from the 16e; the shadows are better exposed, the colours richer. Compared to the subdued shots from the iPhone SE 2022, it's a huge improvement.

Low-light performance is impressive, too. Across a selection of night-time pictures of my back garden, the 16e picked up cleaner detail than the Pixel 8a's Night Sight mode, with better contrast and definition around the dark, tangled tree branches.

While there's no zoom lens, the 48MP sensor resolution means you can capture decent results with digital zoom, which uses the same processing as the full iPhone 16. This is another area where the 16e does better than the Pixel 8a: I barely saw any loss of quality at 2x digital magnification, even when peering closely at fine details.

Overall, I'm beyond impressed by what this camera can capture. It's just as good as the full iPhone 16, unless you want the ultrawide lens, which can improve the look of landscapes and group photos.

Video-recording capabilities are again similar to the iPhone 16's. Resolution tops out at 4K and 60fps, with a slow-motion mode that shoots 1080p at 240fps, and again I can't see any difference in quality or dynamic range between the two phones. Features such as video stabilisation and audio mix are here, too, although the Cinematic and Action shooting modes are missing.

Power boost

The camera isn't the only part of the iPhone 16e that matches its full-price cousin. Inside you'll find the same Apple A18 processor, and the Geekbench benchmark reveals identical CPU performance across the two phones. This means everything feels snappy in day-to-day tasks such as flipping between apps and watching YouTube. Scrolling can sometimes feel choppy compared to premium phones, but that's due to the 60Hz display rather than any performance limitation.

Apple has cut one corner when it comes to graphics. The A18 processor in the 16e has only five GPU cores rather than the six in the iPhone 16, and this has a measurable impact on 3D performance: in 3DMark's Wild Life Original Unlimited test, I recorded an average frame rate of 71fps, whereas the iPhone 16 achieved 98fps.

Thankfully, this doesn't ruin the iPhone 16e for gaming at all. I played several rounds of *Asphalt Legends* without issue, enjoying consistently smooth frame rates and advanced lighting effects.

ABOVE **The iPhone 16e benefits from the same system software as other Apple models**

On charge

Apple claims that the iPhone 16e delivers the best battery life ever on a 6.1in iPhone, possibly because it's the company's first handset to use its custom-designed C1 modem rather than an off-the-shelf Qualcomm chip. However, in our in-house battery test (which includes browsing the internet over mobile data) I found the iPhone 16e lasted 12hrs 41mins on average – effectively identical to the iPhone 16's average of 12hrs 43mins.

Recharging speeds were on a par, too, with the iPhone 16e reaching 32% capacity after 15 minutes of wired charging and 57% after 30 minutes. Standard Qi wireless charging at 7.5W is supported, although the 16e lacks an integrated MagSafe connector for snap-on charging. The good news: you can easily buy a case that has the magnets necessary for MagSafe.

Soft touch

Since the 16e runs the exact same iOS software as other iPhone 16 models, the user experience is mostly identical. However, if you're coming from the previous iPhone SE, you may have to adjust: with Touch ID and the physical Home button gone, you'll need to get into the habit of using swipe gestures to reach the homescreen and access the Control Centre.

Still, you do now benefit from the programmable Action Button. I've configured mine to launch Visual Intelligence (similar to Google Lens, so a visual search tool), an Apple Intelligence feature that's exclusive to iPhone 16 models.

Which brings me to one of the most interesting aspects of the 16e. Despite being the baby of the range, it supports the full set of Apple Intelligence features – including writing tools, notification summaries, Image Playground, Genmoji, Photo Clean Up, Visual Intelligence, enhanced Siri and ChatGPT integration.

While you may be understandably sick of hearing about AI, some of these features speed up tedious tasks or achieve things that weren't previously practical. And the AI suite will only improve with future updates: iOS 18.4, currently in beta, adds cross-app actions and personal context.

I'm not claiming that Apple's AI features are any better than rival offerings, such as Samsung's Galaxy AI or Google AI – a lot depends on your priorities, and the feature sets are improving all the time. Even so, it's good to know that, however things may evolve in the future, the cheapest new iPhone starts from the same baseline as the most expensive ones.

E buy?

The joy of the iPhone SE was that it offered an authentic iPhone experience at a fraction of the cost of Apple's flagship models. The pricier iPhone 16e isn't so compelling in that way, but it could still be a smart, cost-saving alternative to the regular iPhone 16.

"Overall, I'm beyond impressed by what this camera can capture. It's just as good as the full iPhone 16..."

Whether it's right for you depends on how much you care about creature comforts such as the Dynamic Island, the ultrawide camera, integrated MagSafe connectors and extra video features. If you want those things, pay the extra for the iPhone 16. If you're not bothered, then the 16e is a cheaper way to get the same sumptuous OLED screen, almost the same performance and a truly excellent camera – not to mention the full set of Apple Intelligence features. **JOHN VELASCO**

BELOW **Battery life and recharging speeds are on a par with the iPhone 16**

SPECIFICATIONS

6-core Apple A18 SoC • 8GB RAM • 4-core Apple GPU • 6.1in 60Hz AMOLED screen, 1,170 x 2,532 resolution • 5G • 128GB/256GB/512GB storage • nano-SIM • IP68 • 48MP rear camera • 12MP front camera • Wi-Fi 6 • Bluetooth 5.3 • NFC • unspecified battery • USB-C 2 connector • iOS 18.3 • 72 x 7.8 x 147mm (WDH) • 167g • 1yr warranty

Xiaomi 15 Ultra

An exceptional piece of design and hardware for an equally exceptional price, with particular appeal to photographers

PC PRO RECOMMENDED

SCORE ★★★★☆

PRICE 512GB, £1,083 (£1,299 inc VAT) from mi.com

Xiaomi's Ultra smartphones are always eye-catching, but this update takes things to a new level: the Silver Chrome edition of the 15 Ultra is designed to look like a classic Leica camera, complete with faux leather coating, and looks spectacular. I'm not normally a fan of Xiaomi's large circular camera units, but for this inventive design it works perfectly. If you prefer something less showy, there are also plain black and white versions.

The other side of the phone has its own visual charms. The 15 Ultra packs a 6.73in AMOLED display with an adaptive 1-120Hz refresh rate, a huge 3,200cd/m² peak brightness, support for HDR10+ and Dolby Vision, and a fingerprint sensor under the display.

The screen quality is immediately apparent whether you're scrolling through apps or browsing the web. Watching films is even better, with rich colours and perfect sharpness; the 20:9 aspect ratio means black bars at the sides of the picture, but that's an occupational pitfall of watching movies on a phone.

My other caveat is that you have to watch from the right angle. As bright as the Xiaomi 15 Ultra is, catching it from the side can turn the glossy screen into a mirror. This isn't a problem with head-on viewing, though.

Xiaomi's Shield Glass purportedly gives the screen up to 16 times better drop resistance than 2023's Xiaomi 13 Ultra, and there's IP68 water and dust resistance too. An aerospace-grade glass fibre backplate reduces the weight, though at 229g the phone still feels solid in your hand. The 9.5mm thickness means this is also far from the skinniest phone on the market.

Photographer's choice

The Xiaomi 15 Ultra's camera bump encases four discrete Leica-branded cameras. The main, ultrawide and 3x telephoto lenses have 50MP sensors, while the 4.3x periscope zoom uses a massive 200MP sensor. There's much here for serious photographers and videographers to enjoy, with superb levels of control and features such as 10-bit Log video recording and support for all focal lengths.

LEFT The optional Photography Kit adds physical buttons and a 2,000mAh battery

ABOVE The Xiaomi 15 Ultra is a well-designed phone with a stunning display and cameras

"There's much here for serious photographers and videographers to enjoy, with superb levels of control"

I pitted the Xiaomi 15 Ultra against Google's Pixel 9 Pro (*see issue 362, p58*) – arguably the best Android camera phone on the market – and was generally impressed by what I saw. For example, the Xiaomi's photo of a sculpture on the Barcelona beachfront was noticeably darker than Google's, but when I zoomed in it was clear that the 15 Ultra had done a much better job of capturing the smaller details. Indeed, in all of my outdoor photos the Xiaomi's image was darker but cleaner than the Pixel's, whether I was using the main camera or the ultrawide or zoom modules.

Things were a little different indoors; without so much direct sunlight, the Xiaomi 15 Ultra compensated more, and produced brighter pictures. Fine detail suffered, especially in the background, but the overall impression was excellent. As usual, the colour in the Xiaomi's images also looked livelier than the Pixel's naturalistic tones.

The Xiaomi's colour profile works nicely for portraits, too, which are flatteringly warm. The tasteful bokeh effect neatly separated subjects from

the background, with no noticeable fringing. In low light mode the Xiaomi's pictures were again darker than the Pixel 9 Pro's, but still bright – although the Pixel did a better job of extracting detail from the murk.

In all the Xiaomi 15 Ultra produces attractive images with good colour and detail, and no conspicuous post-shot processing. The overall character is on the sombre side, and the zoom isn't as phenomenal as its enormous pixel-count might lead you to expect, but it makes a superb photographic companion.

And there's one final trick: Xiaomi is selling a Photography Kit for £179, which adds a 2,000mAh battery pack, physical zoom and snap button, and a Record button for video. There's even a 67mm filter adapter ring for adding ND, polariser and other filters.

Elite power

Like most of the latest high-end Android phones, the Xiaomi 15 Ultra is powered by Qualcomm's Snapdragon 8 Elite chipset. While this means it's a very powerful handset, its benchmark scores weren't quite up there with the fastest we've seen. For example, the Xiaomi's single-core score of 2,986 in Geekbench 6 was a shade behind the 3,031 achieved by the Samsung Galaxy S25 Ultra (*see issue 367, p70*) and around 12% lower than the 3,386 score of the Apple iPhone 16 Pro (*see issue 363, p70*) with its A18 Pro processor.

The 15 Ultra fell further behind in the multicore test, scoring 9,064 while the S25 Ultra managed 9,829 – likely thanks to Samsung's use of a custom, higher-clocked Snapdragon chipset. The iPhone 16 Pro lagged here, too, however, with a score of 8,306.

At any rate, don't get too hung up on these comparisons. It's enough to know that this chipset now drives the most powerful Android phones on sale and it's partnered here with 16GB of RAM. As a result, the experience of navigating the interface and working in apps is terrifically smooth.

The same goes for graphical performance. The Xiaomi 15 Ultra's score of 10,100 in 3DMark's Solar Bay Unlimited benchmark test is lower than the Galaxy S25 Ultra, which scored 11,140, but in practice I found gaming was seamless and smooth, without any choppiness or stuttering and no noticeable overheating. Unless you're specifically looking for the most powerful phone around, you'll have no complaints about the Xiaomi 15 Ultra's performance.

The 5,410mAh battery inside the Xiaomi 15 Ultra is unusually large, and lasts for ages: three hours of watching YouTube at 50% brightness drained the battery by only 11%, compared to 21% on the Google Pixel 9 Pro.

And for recharging, the 15 Ultra supports ultra-fast 90W wired and 80W wireless charging, although you'll need to source an appropriate first-party charger yourself, as none is provided in the box. The best I had to hand was a 67W supply, which got the battery from zero to 46% full in 15 minutes, and up to 81% after half an hour.

Hyper active

The 15 Ultra runs on Xiaomi's HyperOS 2 – a strange platform that's built on Android 15 but customised to look like iOS in places. For example, it includes split pull-down menus for notifications and a flagrant clone of the Control Centre app. Signature Android touches remain, such as the Discover bar and the standard Settings interface, but it's very different from Google's own Pixel Launcher or Samsung's One UI.

Xiaomi has also built in numerous AI tools, spread throughout the interface. Performance is up and down: for example, the AI subtitle feature impressed me by translating a French video into English, but struggled much more with Korean – and be prepared to read fast, because the text window isn't very big.

You also benefit from the usual AI image-editing features, but again I found these worked inconsistently. While the expand feature generated a plausible extension to a desk, erasing objects often replaced them with other incongruous items: my Android figurine was turned into a green teapot, while the drinks cans sitting next to my laptop were shrunk down into little metal pucks. I also found the "Magic Sky" feature didn't always detect the sky accurately, which is a pretty fundamental problem.

Xiaomi's AI Writing tools include a chat interface, so you can ask the phone to generate, edit or respond to text. As well as answering direct questions, it can change the tone of your written work, summarise, proof-read or expand on something you've already written. This all works well, even if it's questionable whether these are operations you'd want to carry out on a phone.

On top of all this, you get Google's familiar Gemini and Circle to Search features, plus a free three-month free trial of Gemini Advanced. As for future enhancements, Xiaomi pledges four generations of Android system updates, along with six years of security updates. That's short of the seven years promised by Google and Samsung, but surely long enough to see you through to your next upgrade.

BELOW The 15 Ultra's Leica-branded lenses produce fine images inside and out

Final thoughts

The Xiaomi 15 Ultra has all the qualities you'd expect from a premium-priced smartphone. Performance is way beyond most people's needs, the screen is an absolute joy to gaze at, and its capacious battery life means you shouldn't run out of power in the middle of a normal day. Then there's its photography kit, building on top of the excellent Leica cameras, turning this into a proper camera replacement.

"The Xiaomi 15 Ultra has all the qualities you'd expect from a premium-priced smartphone. Performance is way beyond most people's needs"

But I do have quibbles. Xiaomi's own AI features have little to recommend them, especially when compared to what you get with the top-end Google and Samsung phones, and the iPhone-inspired software design isn't to my taste (although I can see that it might appeal to others). And let's not forget the price: £1,299 for 512GB and £1,499 for 1TB of storage are only £50 cheaper than the Samsung Galaxy S25 Ultra.

The thing I like most about the Xiaomi 15 Ultra is the design of the Silver Chrome edition. Xiaomi has brilliantly turned its divisive camera style into the centrepiece of a smart, unique design, which – if you're anything like me – you'll want to be seen with. **TOM PRITCHARD**

BELOW Xiaomi's AI writing tools work well, but it's debatable if you'll ever use them

SPECIFICATIONS

8-core 4.3GHz/3.5GHz Qualcomm Snapdragon 8 Elite SoC • 16GB RAM • Adreno 830 graphics • 6.7in 120Hz AMOLED screen, 1,440 x 3,200 resolution • 5G • 512GB/1TB storage • dual nano-SIM • IP68 • quad 200MP/50MP/50MP/50MP rear cameras; 32MP front camera • Wi-Fi 7 • Bluetooth 6 • NFC • 5,410mAh battery • USB-C 3.2 Gen 2 connector • Android 15 (4 major updates) • 75 x 9.4 x 161mm (WDH) • 226g • 2yr RTB warranty

Nothing Phone (3a) Pro

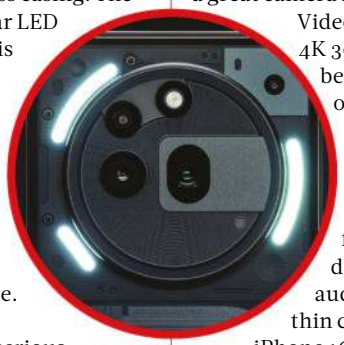
This mid-priced phone could be faster, but its striking looks and optical zoom mean it remains a strong choice

SCORE ★★★★☆

PRICE £374 (£449 inc VAT)
from nothing.tech

Despite the "Pro" tag, the Nothing Phone 3a Pro is very much a value proposition. For £449 it comes with a generous 256GB of storage – twice as much as the Pixel 8a (*see issue 358, p74*) and iPhone 16e (*see p72*) – a big screen and a powerful camera setup. The regular Phone 3a opposite is even cheaper, for reasons that will become clear.

The design sticks with the see-through style of previous models. This combines a sleek feel with a helping of hi-tech futurism, providing a peek into the inside: micro-screws and cable ribbons are clearly visible through the sturdy glass casing. The distinctive "Glyph" rear LED display is here, too. This not only adds to the conversation-starting aesthetic, but has a functional element – you can make it light up for notifications, or even (for example) see the progress of an Uber ride.



At the back, a large hump asserts this as a serious camera phone. It's positioned in the middle of the casing, so the phone doesn't tilt to one side when you lay it down.

The 6.8in 120Hz AMOLED display is slightly bigger than last year's 6.7in Phone 2a (*see issue 356, p73*), but more significantly the peak brightness has increased from 990cd/m² to 1,259cd/m². This, plus wide viewing angles, means it looks great even under the sun, with bold colours and contrast.

Another big improvement is the camera array. The Phone 3a Pro packs a 50MP main shooter, an 8MP ultrawide camera and a 50MP telephoto with 3x optical zoom – a rare treat for a phone at this price. There's also a beefy 50MP selfie camera around the front that can shoot 4K video.

Quality-wise, the main camera holds up well against the iPhone 16e and pulls in more dynamic range than the Pixel 8a. The optical zoom means the Phone 3a Pro also reveals cleaner detail in long-range shots than its rivals, and I was equally impressed by the detail it captured in macro mode. Colours are conservative to the point of being drab, but it's generally a great camera setup.

ABOVE The Nothing Phone 3a Pro's unique design is sure to set tongues wagging

Video recording tops out at 4K 30fps; that's a step behind the 60fps we often see, but the camera's great handling of dynamics makes it easy to obtain good-looking footage. The only disappointing aspect is audio: speech sounds thin compared to the iPhone 16e, and there's no equivalent to Apple's clever tools for cleaning up your sound.

Inside, the Phone 3a Pro uses a mid-range Qualcomm Snapdragon 7s Gen 3 chip. As a result, it achieved a significantly lower score than the Pixel 8a in Geekbench 6 (1,166 versus 1,581 in the single-core test, 3,275 versus 4,093 across all cores), and was only around a third as fast as the iPhone 16e. This isn't a problem for everyday use, though: whether launching apps or doomscrolling, I didn't notice any difference in responsiveness between this and rival phones, and the 120Hz refresh rate makes it feel smooth.

Gaming performance suffers a little more. The Phone 3a Pro achieved only around half the score of the Pixel 8a in 3DMark Wild Life (4,192 against 8,983). While games were playable, frame rates weren't as smooth as I'm used to from high-end phones.

In our battery tests, the 5,000mAh unit ran for 14hrs 33mins – well beyond the 12hrs 41mins of the iPhone 16e and the Pixel 8a's 11hrs 21mins. Although the regular Phone 3a lasts for even longer, the 3a Pro had more than enough juice to power me through a solid day's usage. The lack of wireless charging is a shame, but 50W wired charging means you can go from empty to 70% in 30 minutes.

Not everyone loves the heavily stylised Nothing OS software, but it's one of my favourite custom Android experiences, and this latest release offers more widgets and customisations than ever. It dips a toe into AI, too, with a feature called Essential Space. You simply tap a physical button on the right side of the phone to capture a screenshot, or hold it down to record a voice memo; this is then analysed and catalogued by the AI, and can be turned directly into notes, reminders and tasks in the Essential Space app.

The idea works perfectly well, but I wish it were more proactive; I also wish there were other AI features to play with, as currently the Nothing Phone 3a Pro lags a long way behind the Apple Intelligence capabilities of the iPhone 16e or Gemini AI on the Pixel 8a. Still, Nothing pledges three years of major Android updates for this phone, plus six years of security updates, so we'll probably see more AI updates in the future.

LEFT The three cameras are superb for such a low price

"The optical zoom means the Phone 3a Pro packs cleaner detail in long-range shots than its rivals"

BELOW The Phone 3a series looks great no matter which colour finish you choose

While the Nothing Phone 3a Pro isn't the fastest phone around, it offers great quality for the price thanks to its triple camera system, standout design, vibrant AMOLED display and battery life that easily beats its rivals. If you're looking for a high-end experience on a budget, its most obvious rival is the even cheaper Nothing Phone 3a we review opposite. **JOHN VELASCO**

SPECIFICATIONS

8-core 2.5GHz/2.4GHz/1.8GHz Qualcomm Snapdragon 7s Gen 3 SoC • 12GB RAM • Adreno 710 graphics • 6.8in 120Hz AMOLED screen, 1,080 x 2,392 resolution • 5G • 512GB storage • IP64 • triple 50MP/50MP/8MP rear cameras • 50MP front camera • Wi-Fi 6 • Bluetooth 5.4 • NFC • 5,000mAh battery • USB-C 2 • Android 15 (3 major updates) with Nothing OS 3.1 • 78 x 8.4 x 164mm (WDH) • 211g • 2yr warranty

Nothing Phone (3a)

Aside from storage, you sacrifice little when choosing the big-value Phone 3a over its Pro sibling

SCORE ★★★★☆

PRICE 128GB, £274 (£329 inc VAT) from nothing.tech

We were impressed by the £449 Nothing Phone 3a Pro, as you can see opposite, but the standard Phone 3a squishes the price even further. You'll pay £329 for the base model with 8GB of RAM and 128GB of storage, which includes a telephoto camera and a spacious screen. Or for £50 more enjoy an extra 4GB of RAM and double the storage.

The design is classic Nothing, with its lit-up LEDs and stylish swooping lines. "What's with the *Blade Runner* phone?", my daughter asked when she spied it on my desk, and she meant it as a compliment.

Personally, I'm not such a fan: to my eye, the phone looks like it hasn't been fully assembled. It feels sturdy, though, with an IP64 rating that means it will survive a spray from multiple directions.

The screen is just as good as on the Pro edition. It's a 6.8in AMOLED panel, with a dynamic refresh rate that automatically ranges between 30Hz and 120Hz and a measured peak brightness of 1,370cd/m². I never had a problem seeing the display, even when it was sunny, and videos looked vibrant from an assortment of viewing angles.

Low-cost phones often cut corners on the camera hardware, but the Phone 3a has a dedicated telephoto camera alongside a 50MP main lens, an 8MP ultrawide and a 32MP front camera for selfies. These produce more than satisfactory results, with good colour balance and lots of detail, even in dull lighting. I captured lovely clean pics at 4x magnification, too, combining the optical and digital zoom.

Fine elements and edges at times look softer than on other phones, especially in low light; portraits shot with the rear camera can also look a little pale and lifeless. In all, though, it's a much better camera setup than you've any right to expect at this price.

ABOVE At only £329, the Nothing Phone 3a is a veritable bargain

The processor inside the Nothing Phone 3a is the same Snapdragon 7s Gen 3 as found on the Pro model, so in terms of raw performance it's indisputably a lesser phone than the £499 Pixel 8a or the pricier still Apple iPhone 16e. In ordinary use, though, it's perfectly snappy, and gaming isn't bad, either. While my colleague John Velasco experienced choppy graphics when playing his choice of games on the Phone 3a Pro, my own experience of playing *PUBG Mobile* on the Phone 3a was impeccable. I'd have no complaints about using this as my everyday phone.

The 5,000mAh battery provides plenty of longevity. In our tests, the Phone 3a provided an excellent 15hrs 24mins of web surfing on a full charge, beating the average smartphone by a massive five hours, and also incidentally running for almost an hour longer than the Phone 3a Pro. While there's no wireless charging, a compatible wired charger will let you charge at 50W, and this took me from a drained device to a 72% charge in half an hour.

PC PRO RECOMMENDED

"It's a long-lasting phone with a unique design, a gorgeous display and high-quality cameras – including an optical zoom"

LEFT The system software has a unique take on Android 15

BELOW The phone feels sturdy and has an IP64 rating

As ever, Nothing's system software has a feel of its own. This latest version is built on Android 15, but looks like no other implementation of Google's OS. The dot-matrix-style font and circular icons can be daunting if you aren't accustomed to it, and while I got the hang of it I never fell in love.

The software also includes the new AI-powered Essential Space feature. As on the Phone 3a Pro, this provides a virtual space for working with audio and screenshots recorded with the new Essential Key. Again, I never got used to the Key's location directly below the power button: I captured too many accidental screenshots when I merely wanted to put the Nothing Phone 3a to sleep.

Still, I appreciated being able to review and organise my content in the Essential Space app. I only wish the idea were more developed: I'd like a way to create and write a note directly in Essential Space rather than having to use the Essential Key, for example.

Thankfully, we can expect improvements in future, and maybe additional AI features too, as Nothing promises three years of Android updates for this phone, along with six years of security updates. While that's a lot less than the seven years Google promises for the Pixel 8a, it's a good deal for the price.

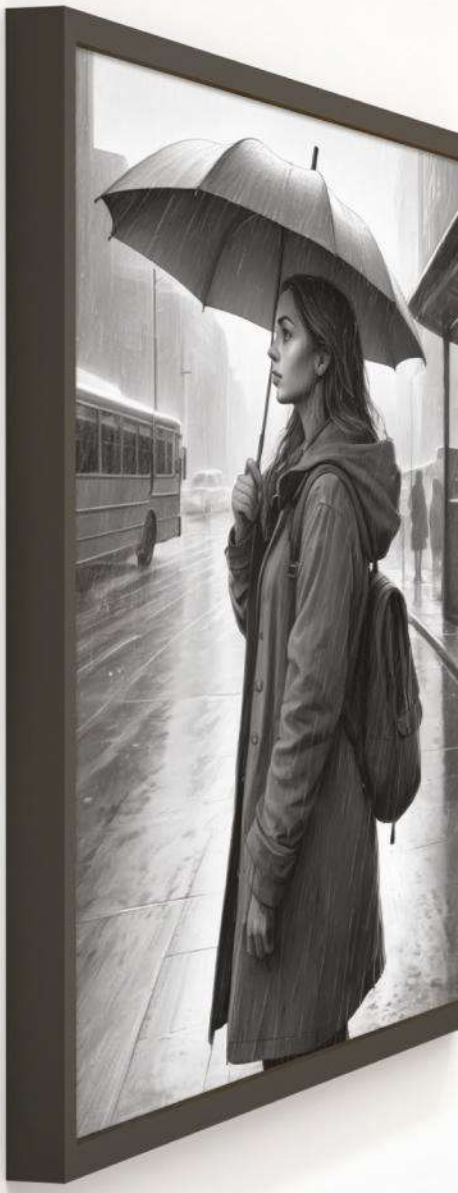
That rather sums up the Nothing Phone 3a. It's a long-lasting phone with a unique design, a gorgeous display and high-quality cameras – including an optical zoom that few phones in this price bracket can match.

There are some nits to pick. Performance is fine rather than great, the design and software interface are an acquired taste, the Essential Space feature feels underdeveloped, and currently the phone lacks any other AI capabilities. The baseline 128GB capacity is also challenging.

If you want more storage and speed, though, you have little option but to pay more. For those wanting to keep expenditure to a minimum, the Nothing Phone 3a hits the mark: you won't find a better all-round phone at this price. **PHILIP MICHAELS**

SPECIFICATIONS

8-core 2.5GHz/2.4GHz/1.8GHz Qualcomm Snapdragon 7s Gen 3 SoC • 8GB/12GB RAM • Adreno 710 graphics • 6.8in 120Hz AMOLED screen, 1,080 x 2,392 resolution • 5G • 128GB storage • IP64 • triple 50MP/50MP/8MP rear cameras • 32MP front camera • Wi-Fi 6 • Bluetooth 5.4 • NFC • 5,000mAh battery • USB-C 2 • Android 15 (3 major updates) with Nothing OS 3.1 • 78 x 8.4 x 164mm (WDH) • 201g • 2yr warranty



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AI IMAGE GENERATORS

AN EXPLOSION OF AI IMAGE GENERATORS HAS INVADED OUR LIVES, BUT WHICH ONES ARE BEST FOR PERSONAL AND BUSINESS USE? WE PUT EIGHT TO A THOROUGH TEST

Not a day goes by without an AI developer claiming that their product is the answer to one of life's bugbears. Whether it's cutting hospital waiting times, assessing claims or making us safer drivers, there's seemingly no end to AI's talents. And nowhere is this more true than its capacity to generate wholly imaginary images. This month, we compare eight leading contenders on their ability to produce realistic, useful graphics in response to six diverse prompts.

The prompts themselves, which you can read in full from p88 to p93, were designed to generate a series of images that we could compare directly. Which makes this sound easy, when it wasn't: weighing the benefits of one service against another is a huge challenge, given their diversity. Microsoft Designer, for example, works as a standalone generator as well as living inside several Microsoft 365 applications. Artbreeder has unique tools well suited to drawing characters for fiction and video games. DALL-E uses a conversational workflow, while Midjourney lets you embed parameters within your prompts to add weight to specific elements.

Where a platform offers several models tailored to different kinds of output, we chose what we believed to be the most appropriate model for each test. We frequently re-ran tests using different models to give each platform the best chance of performing well, and occasionally reworded a prompt if a platform didn't quite get what we wanted on the first attempt. For one test in particular, in which we prompted for podcast artwork, rewording was necessary across the board in our attempt to include non-London landmarks. On another test, we had to reword a prompt for one service to remove references to well-known films.

Although each review includes comments on the images themselves and the process involved in creating them, we have included samples from each service in the gallery pages, which follow the reviews. Bear in mind that using our prompts to generate your own images, even on the same platforms, won't necessarily generate the same results as we received. Further, while we generated in excess of 400 images in our tests, space constraints mean we've only been able to publish one example per test from each candidate.

The image selection is therefore the result of subjective judgements on our part, based on how well a service responded to the prompt, aesthetic merit, or interesting and unusual features.

CONTRIBUTOR Nik Rawlinson

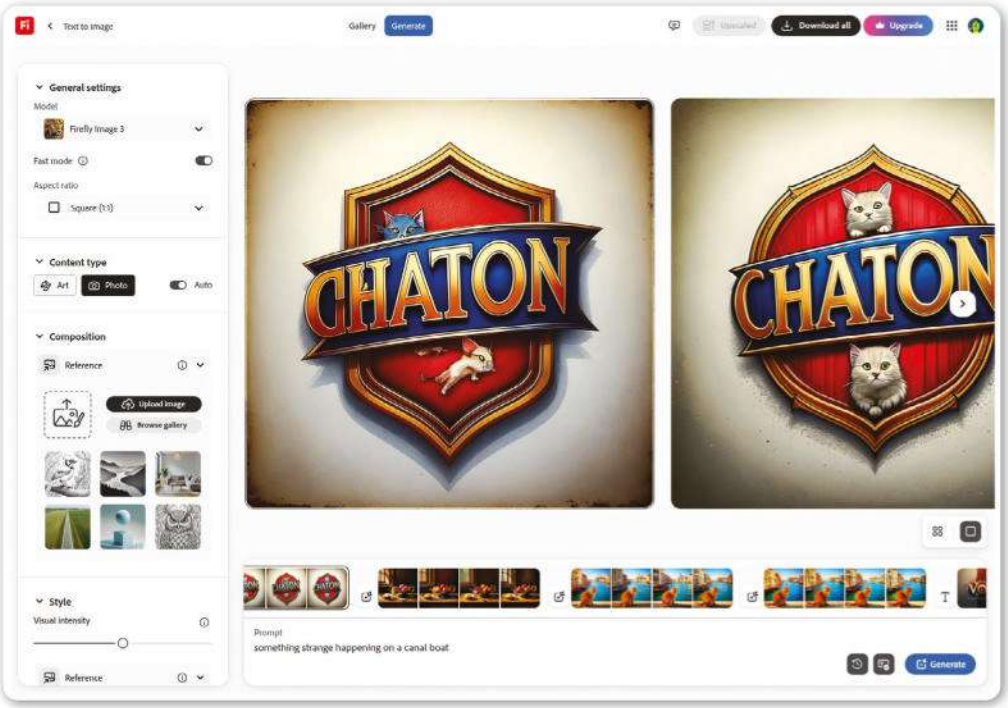
ADOBE FIREFLY

PROS Conversational workflow • great logo response • expressive oil paintings • diversity in human depiction

CONS Difficulty steering UK landmarks away from London • Venice pictures could have been better

SCORE ★★★★☆

PRICE From free to £29 per month from firefly.adobe.com (credits also included with Creative Cloud subscriptions)



If you're already a Creative Cloud subscriber, what are you waiting for? On the All Apps plan, you get 1,000 Firefly generative credits a month, and 500 if you're on a single app plan or have a paid subscription to Adobe Stock. Lightroom and Photography 20GB plan subscribers receive 100 credits apiece, and if you have multiple subscriptions, your credits are aggregated.

Non-CC users needn't feel left out. If you sign up for a free account then, per Adobe, you "may be provided with a limited number of generative credits at no cost", although the number may be subject to change. Or, you can do what we did: sign up to the £9.98 monthly plan, which landed us 2,000 credits a month. Adobe's full credits policy is at **tinyurl.com/368firefly**.

Several controls in a logical sidebar supplement Firefly's prompt box. Here, you can upload reference shots for composition and style, control how much they influence the output, manually select colour and tone (think pastel, monochromatic, vibrant), tweak the lighting, and even change the camera angle. The latter includes options such as macro, wide angle and "photographed through window". You can also use a conversational flow of prompts and feedback, as you would with DALL-E, but we didn't always find it easy to improve on the initial output.

Image generation results

Our Venetian cats weren't cleaning themselves (*see p88*), and the scenes were oversaturated. We reiterated the cleaning requirement, asked it to reduce the saturation, then selected which of the four first attempts we preferred to use as its starting point. The saturation seemed not to lessen on two subsequent runs, and the cats stubbornly refused to clean themselves.

We had a similar experience with the oil painting test. The first set of results was generally good, but our preferred composition included a bowl of yoghurt (we assume) rather than cheese. So, we selected that as the reference image and prompted "improve the cheese in this picture". In one of the four results this delivered, the fruit bowl and its contents were entirely made of holey cheese, while only one of the four images included any fruit. Two of them had been moved out of the kitchen we'd specified, to outdoor locations with mountainous backdrops.

Overall, though, the oil paintings were good. Expressive, with thick paint and obvious knife work, they looked like photos of gallery exhibits. Likewise, the logos Firefly generated were by far the most exciting of any that we saw in these tests. They included colours drawn from the French flag, all four renderings included the brand name and, in three of them, it was spelled correctly. A second pass to add fine details resulted in something we'd be proud to put on a letterhead.

The poster artwork was colourful and engaging, and the pencil sketches were likewise skilfully produced. As with other services on test, we went through a couple of iterations with the sketches to make them look like they were done in a hurry. The results were striking and confident, although upon enlarging them we don't think they would pass as hand-drawn pencil work.

ABOVE Firefly produced a series of dynamic, engaging logos in our tests

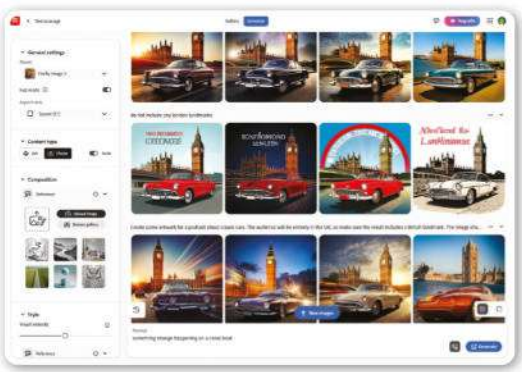
Firefly performed well, but some of the results fell short compared to those produced by Google ImageFX, DALL-E and Midjourney

The photorealistic pictures of Venice were less successful. While the cats were proportionally accurate, they sometimes got caught up in the background, with the fur of one being affected by the water, and another's ear becoming part of a building. Some of the buildings themselves looked like textures applied to 3D wireframes, which spoiled the photographic effect.

Many of the 20 podcast cover artworks we generated included Big Ben, Parliament or buildings in similar configurations. Prompting "only include landmarks from the British Midlands or Scotland" gave us more diverse compositions, in one of which the building – still a similar shape to Parliament, but not the building we know – was sitting on a small island. None of them included the name of our podcast.

Firefly performed well overall, but some of the results fell short compared to those produced by Google ImageFX, DALL-E and Midjourney. We loved the oil painting and logo – and the fact that where humans were depicted the subjects demonstrated broad ethnic and racial diversity. Firefly is well worth giving a spin if you're a Creative Cloud user. Even if you're not, the free tier should keep you busy for a couple of hours and, if you decide to subscribe, the generous credit balance is very fairly priced.

BELOW We had to tweak the prompt to convince it not to include Big Ben among the UK landmarks



ARTBREEDER

PROS Character generation tools • splicer for mixing images and styles • addictive generation tools • good text

CONS More photorealistic images seen elsewhere • private image generation only available on paid plans

SCORE ★★★★☆

PRICE From free to $39 per month from artbreeder.com

Artbreeder offers a range of prompt-based tools, supplemented by alternative image generators that could help visualise graphics for unrelated projects – for example, characters for a novel or background actors in video games. The Tuner tool is a case in point: input a regular prompt, such as "25-year-old woman in medieval England", then drag sliders to change her hair colour, neatness, age, whether she's happy or sad... the list goes on.

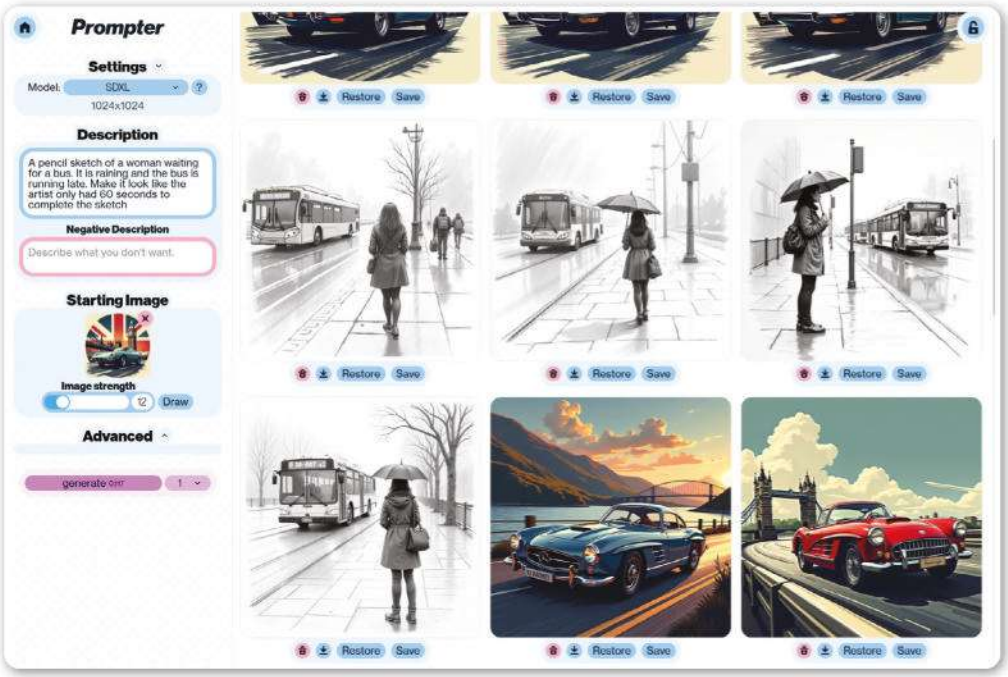
If that doesn't deliver what you need, try the Splicer, which combines objects and styles from two pictures to throw up a third. Or the Collager, where you combine your own sketches with uploaded objects and a prompt.

You can try all of these for free, but might soon run out of credit if you're using more ambitious options, such as complex models generating multiple prompt-based images from scratch.

The cheapest paid-tier – Starter – includes 100 credits a month for $8.99 or 1,200 a year for $90. However, this sphere is so quick-moving that we'd hesitate to commit for that long. Advanced buys 275 credits for $19 per month, Champion 700 credits for $39, but you might as well start at the entry level and renew or upgrade early if you run out of credits. Besides, 100 credits should be enough to generate around 1,000 images a month using the Stable Diffusion XL (SDXL) model.

Switching to a paid plan brings other benefits, including higher-resolution downloads, synchronising output to Google Drive, and the option to generate images in private.

The Prompter tool works more like the other image generators on test, basing its output on your written descriptions. You can select your preferred model when entering a prompt, and the option you choose determines how much it deducts from your credit. Some models let you upload an image as a starting point, and some let you specify negatives to outline what the result should avoid.



ABOVE **Artbreeder lets you choose from several models**

You can see how much each job costs before actioning it, and adjust the number of results you want. What you can't do is preview the effect of each model, so you may want to run your prompts several times with different options until you get used to their characteristics. That way you can see the effect each has.

For example, we found that our sketch test was heavily influenced by the chosen model, with the SD 3.5 Large option the most accomplished (and most expensive, by a significant margin). You can specify the size and proportions of the output using UI controls and, as with the other services on test, we found that the selected proportion parameter was used in preference to any equivalent instruction in the prompt.

Image generation results

We generated our Venetian cat using the SD 3.5 Large, Flux and SDXL models but weren't entirely convinced by the results. It did a better job when we switched from the Prompter to the Composer tool, where water was very well handled, but the result didn't rival the best result produced by ImageFX. None of the cats it produced were cleaning, as we'd requested, but they did have the correct number of feet. Not a given.

The oil painting was realistic, and the battered canvas in one result had convincing nicks and wrinkles. The initial pencil sketch, however, was a little too neat for our tastes. When we told it to "make it look like the artist only had 60 seconds", two results looked like they could have been filters on a photo, but others were more expressive.

Artbreeder focused on Big Ben, Tower Bridge and the Houses of Parliament when we asked it to include British landmarks in our podcast artwork. When we added a specific prompt not to use London landmarks it generated a further three images featuring Big Ben. Our third attempt requested landmarks from the British Midlands or Scotland, resulting in one image of Tower Bridge, a mountainous scene and one that could well have been a loch in the Highlands. Only two of the ten generated images included our specified podcast title, in both cases clearly rendered and correctly spelled.

This is often suggested as a tool for creatives looking to define characters for other projects and, on that score, we can't disagree

Text was also well handled in the logo test, with all renderings easy to read and just one spelling mistake in ten images. The designs weren't as inspiring as we've seen elsewhere, and only two included kittens, as suggested by the word "chaton".

Artbreeder is fun to play with, and while we often preferred the results we got from ImageFX, DALL-E and Midjourney, tools such as the Tuner have uses far beyond raw image generation. This is often suggested as a tool for creatives looking to define characters for other projects and, on that score, we can't disagree. Indeed, we'll be returning to use it for precisely that purpose in the future.

BELOW **The splicer is a fun tool that lets you combine images to generate results**

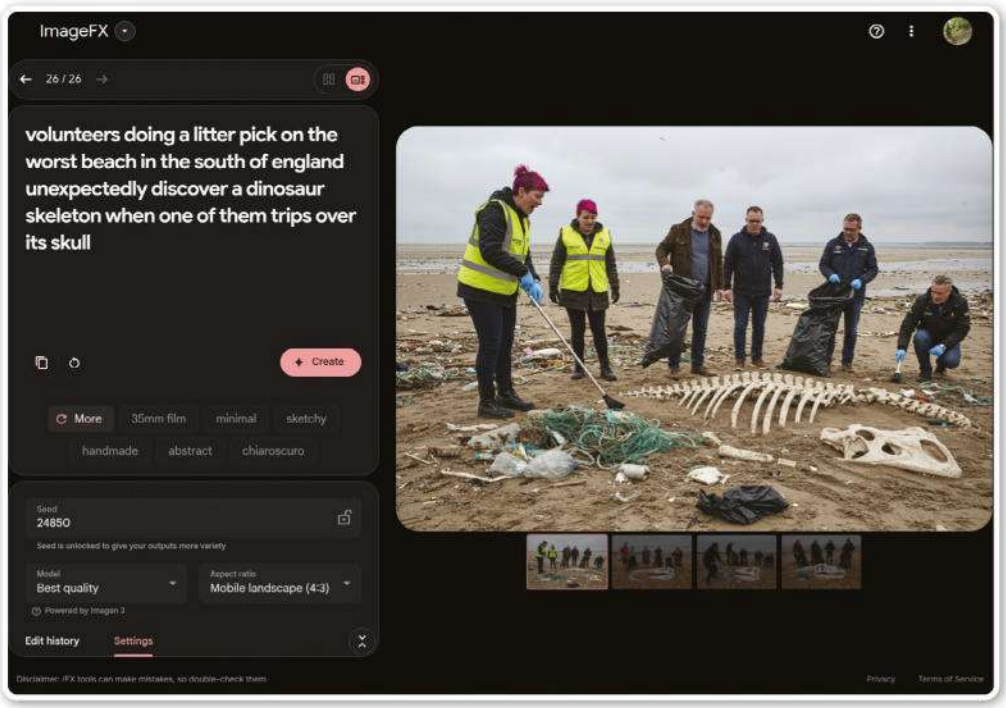
GOOGLE IMAGEFX

PROS Excellent photorealistic image generation • price • generally good text rendering

CONS Difficulty generating UK landmarks outside London • not a collaborative workflow

SCORE ★★★★★

PRICE Free **from** tinyurl.com/368imagefx



As a Google Labs product, ImageFX sits beside other "experiments" such as GenType for producing AI-generated alphabets, TextFX for playing with language components, and MusicFX, which uses prompts to generate music.

The quality of the output is difficult to criticise, so the fact that it's free to anyone with a Google Account is particularly impressive. It's also fun. After running through our test prompts, we started to explore more esoteric options. "A badly framed holiday photo taken in the Algarve that just misses a woman proposing to her boyfriend because it was slightly out of the frame" delivered what could well have been several poorly shot beach photos with shallow depth of field, selective blurring and hands reaching into the frame.

We could easily have believed that "volunteers doing a litter pick on the worst beach in the south of England unexpectedly discover a dinosaur skeleton when one of them trips over its skull" had been taken straight out of a local newspaper, and "show me what the likely environmental impact will be if we continue using AI to generate images for the next 50 years" was not a pretty sight.

We generated dozens of images in our tests and didn't hit the fair use cap, whatever that might be. It's not revealed on the site and Gemini, Google's AI chatbot, explains that "the exact number of images you can generate per day is not publicly disclosed. If you reach your limit, you will be notified, and you can simply try again the next day". Bear that in mind, and try to be specific with your prompts, as it isn't possible to use previously generated images as the basis of new ones.

Our sketch test was a case in point. The first set of results was good, but didn't look like they had been dashed off in a hurry, so we asked it to make them look like the artist had been pushed for time. After considering this prompt, it gave us super heroes, architectural outlines and a lorry for hauling logs, rather than the woman at the bus stop we'd asked for.

Google has implemented what it called "expressive chips" at the bottom of the prompt box. These are suggestions, such as "sketchy" or "painting", which you can add to the prompt with a single click. When you do, they're integrated as embedded menus which, when clicked again, give you alternatives such as "impressionist" or "hyper realistic". We didn't always find that they delivered what they promised, with our "impressionist painting" of students in a lecture theatre looking like a photo.

Other times, it flat out ignored our instructions. This was particularly evident when trying to incorporate anything other than Big Ben and the Houses of Parliament when we asked for British landmarks in our podcast artwork, which was a criticism we could make of every service on test. We added "NO LONDON" to one prompt, which resulted in artwork showing a car in London (again), to which it had added the words "NO LUDDASTS" and "NO LUNDON" on two of the results.

A pencil sketch of a woman waiting for a bus. It is raining and the bus is running late
sketchy
photorealistic
intricate
handmade

LEFT Expressive chips, which appear at the bottom, render as drop-down menus when clicked

ABOVE The poses and expressions of the people in this image give a heightened sense of reality

PC PRO RECOMMENDED

The quality of the output is difficult to criticise, so the fact that it's free to anyone with a Google Account is particularly impressive

Image generation results

ImageFX produced the best cat on a Venetian canalside of any model on test. Bet you never thought you'd read that sentence in *PC Pro*. Lighting, fur and surroundings were spot on, and although seven of the cats had five paws each, this eighth example was a convincing masterpiece. Its rendering of a Vermeer-inspired still life was equally impressive, with subtle lighting and detail in the fruit and cheese subject.

It did less well on its first pass at the business logo. Several other models spotted that "chaton", the word we asked to be included, is kitten in French, and included cat elements, but three of the first four logos here were just the word "chaton'" and the fourth was adorned by a cut jewel. When we asked more specifically that it include the meaning of the word, it produced what we were after, although the brand name was shortened to Chato in one instance.

On the whole, ImageFX did a great job of incorporating words into our artwork. They were clear, while the chosen fonts were appropriate to the underlying image, with an elegant typeface on the classic cars podcast artwork, and text that was clearly inspired by *Back to the Future* and *The Goonies* in the 80s disco poster.

Overall, ImageFX is a very impressive platform. It's quick, versatile and, best of all, free.

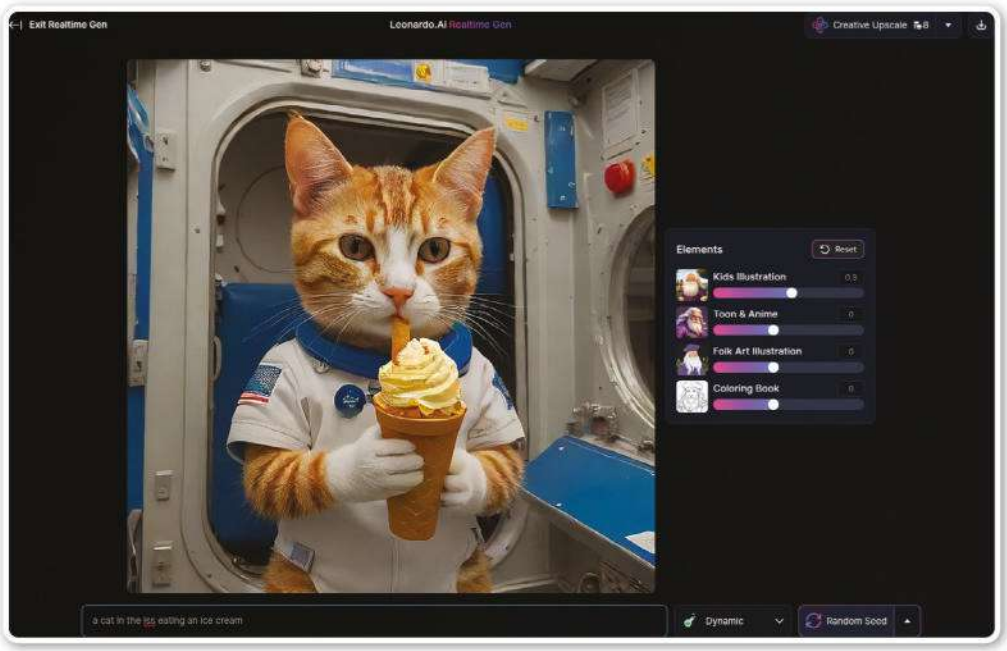
LEONARDO

PROS Extremely fast • free tier quota resets daily • workflow balances prompts with traditional controls

CONS No private image generation on free plan • inconsistent quality

SCORE ★★★★☆

PRICE From free to $60 per month from leonardo.ai



When using Leonardo's free plan, all of your creations are public, as they are with the lower-tier Midjourney plans. You're also limited to 150 fast tokens daily. Although that sounds a lot, our prompt for a photorealistic cat ate up 40. You can't generate anything larger than "medium"-sized images with a free plan, can't generate images privately, and don't get access to the most advanced features, so there are plenty of reasons to upgrade if you find it's a platform you like. Some functions incur lower charges, such as unzooming – currently in beta – which reveals more of an image's surroundings and costs five tokens. Removing a background deducts two.

Alongside the regular image size presets, there's a slider like the one in Midjourney to increment between portrait and landscape, as well as presets optimised for social media, TV and even cinema use. In our tests, including orientation and proportion information as part of the prompt was ignored in favour of this setting. This was a common behaviour across the platforms on test.

While it's always worth typing a comprehensive prompt, playing with the options in the sidebar before generating your image will pay dividends. That's particularly true when it comes to selecting a model: some, such as Flux Dev, consume credits more quickly than others. When we switched from this to the Graphic Design model for our poster artwork, the levy dropped from 40 to 14 tokens, which is significant.

Graphic Design and Dev Flux are only two of several models tailored to realistic photography, anime and concept art, among others, which you can supplement with a style such as acrylic or game concept. If you don't know exactly what you're after, you can ask Leonardo to use its initiative to pad out your prompt with more detail, or switch to the Realtime Canvas and start sketching your idea. A rudimentary stick person with a sword and shield was sufficient to produce a detailed fantasy warrior in our tests.

When you first log in, you'll land in Classic Mode, which works much like the other services on test, generating four images in response to each prompt – unless you've changed that number. However, Leonardo has recently introduced Flow State, which generates an endless scroll of prompt responses at impressive speed. You can download any that you want, generate iterations of a close match, or use them as start points from which to revisit your original prompt, back in Classic Mode.

Elsewhere, you'll find a universal upscaler, where prompts influence how it increases the pixel count, and there's a smart real-time generation engine, which demonstrated the blazing speed of the platform: the rendered image really does keep changing as you type in the prompt box. If you have trouble visualising finished images before prompting, this could well be what you need.

ABOVE The real-time generator literally updates the picture as you type

Image generation results

The photorealistic cat was a little too cutesy to be convincing in Classic Mode (Flow State put in a better performance), although three of the four examples that it produced had the correct number of paws, which was a good hit rate. Only two of them were cleaning themselves, which had been a requirement of our prompt. It performed well in the oil painting test, particularly where convincing light reflection suggested that the artist had been generous in laying down their paint.

Three of the four disco posters were initially obscured by a warning that the result might be explicit, but unless it was because of the odd misplaced leg, we couldn't see why. Our reference to *Back to the Future* was taken quite literally (Marty- and Doc-like characters were identifiable), though *The Goonies* was less evident.

Leonardo is extremely fast and the interface does a great job of balancing traditional controls and prompt-based direction

That same content warning appeared on our podcast artwork, although once again it wasn't clear why. The UK landmarks in three of the four results showed Big Ben and the Houses of Parliament, and the fourth was an unidentifiable city street. We repeated the prompt, adding "do not include London or London buildings in the pictures", and ended up with four new pictures featuring Big Ben. None of the images from either prompt included the name of our podcast, as we'd requested. The name of our business – Chaton – appeared correctly in one of our logos and partially in another. Each logo included a cat or kitten.

BELOW Flow State mode generates a stream of images

All in all, a good performance. Leonardo is extremely fast and the interface does a great job of balancing traditional controls and prompt-based direction to help you get the result you're after. We weren't always as convinced by the output as we were by some of its competitors, but it's fun to use and well tooled for beginners or those who need some help when prompting for artwork.

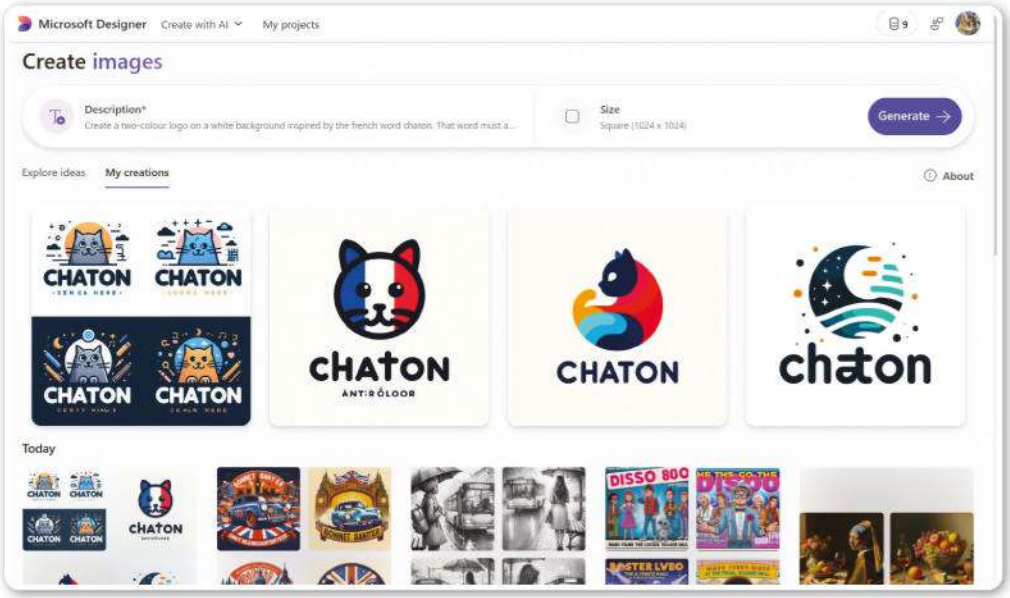
MICROSOFT DESIGNER

PROS Good logo generation • very strong on cartoon-like artwork • flexible in-browser editing • prompts well understood

CONS Text can sometimes be nonsensical • what you get for your money should be clearer

SCORE ★★★★☆

PRICE From free to £19 per month as part of Copilot Pro from designer.microsoft.com



You may have come across Designer's tools inside Microsoft 365 apps, where you can add images directly to your documents and presentations. For this Labs, we used it through the browser.

Designer operates on a freemium basis. You're awarded a certain number of free credits every month, which you can spend on generating images. If you're using a free Microsoft account, you'll start the month with 15 credits, of which one will be deducted for every interaction. You can't top up your credits; your only option if you run out is to upgrade to a Microsoft 365 Personal account (£8.49 a month or £85 a year), which increases the credits "up to" fourfold.

Note, though, that the same balance is used for other Copilot interactions, such as drafting a document in Word, so you may not be able to spend them all in Designer. To go beyond that, you're looking at the £19 a month for the Microsoft Copilot Pro tier, which awards you "at least" ten times more credits but for which there's no annual plan. We'd rather Microsoft set out the limits more clearly, rather than using terms such as "up to" and "at least".

We also found that our credits didn't always buy us the same number of images. Our Venetian cat prompt generated four results, for example, while the Vermeer-inspired oil prompt initially delivered just two. One pass of the podcast artwork split the difference, giving us three options to choose from.

Once you've generated a result you're happy with, you can download, copy or send it to your phone. You can also open it in the web-based editor, where you can remove, blur or change the background colour; adjust brightness, contrast and saturation; crop; or apply selective edits courtesy of a clever selection tool that recognises object boundaries so you can select them with a single click.

However, while you can edit generated images – or your own uploaded photos – you can't use one generated image as the starting point for another the way you can in Midjourney. This is true of most of the other generators on test.

We repeated several of our tests in Copilot via the browser sidebar, and while the pictures were often stylistically similar to those generated by Designer, the workflow was much closer to that of working with DALL-E. We could type freeform prompts, as we did in Designer, and follow up with natural language feedback. For example, we used "make it look even more rushed" on the sketch, "can you make it landscape orientation rather than square" for the Venetian scene, and "don't include London in the landmarks" for the podcast artwork. The first of those amendments worked, but while the second and third generated new images they didn't conform to our specific amendment.

Image generation results

Text was clear where it appeared, even if it didn't always make sense – and, while beautifully rendered, we needed to do some editing to remove it from some of the graphics. Our instruction to use films like *Back to the Future* as inspiration for our poster was clearly noted with stylised but recognisable characters in several artworks.

The text was successfully handled in our podcast artwork with variations on Bonnet Banter

ABOVE The clean interface puts the prompt box front and centre

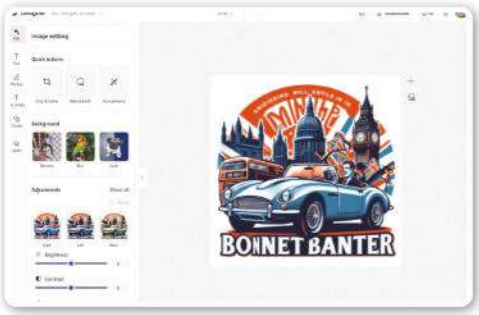
While you can edit generated images – or your own uploaded photos – you can't use one generated image as the starting point for another

appearing in each result. Union flags, Big Ben and St Paul's Cathedral were prominent in the results, along with some familiar-looking cars. When we repeated this prompt and appended "DO NOT USE ANY BUILDINGS OR IMAGERY FROM LONDON IN THE RESULT", the three images it served up all featured at least one and sometimes two instances of Big Ben, the Houses of Parliament and what could be Westminster Bridge, but no other recognisably British landmarks.

The pencil sketches were perhaps too good to be believable. They were neat and detailed and would look great in a comic, but didn't have the looseness or natural feel of those produced by Midjourney. It redressed the balance somewhat in the logo test, spitting out seven options, of which we could have run with six. It correctly incorporated the word "chaton", identified that it translated to "kitten", and in one result included the colours of the French flag to drive the point home. It also had the cat in our Venetian photo cleaning itself. However, the "photos" themselves looked like they were pulled from a video game, one of our gondoliers had sticks for legs, while feel pity for the cat that had two tails.

Overall, then, generally good if not always perfect results from Microsoft Designer. As a means of generating engaging graphics for general use it's a great first step, but we would like a subscription tier separate from Microsoft 365 and Copilot Pro – or at least a way to top up credits on a PAYG basis.

BELOW The browser editor lets you play with backgrounds and enhance your image



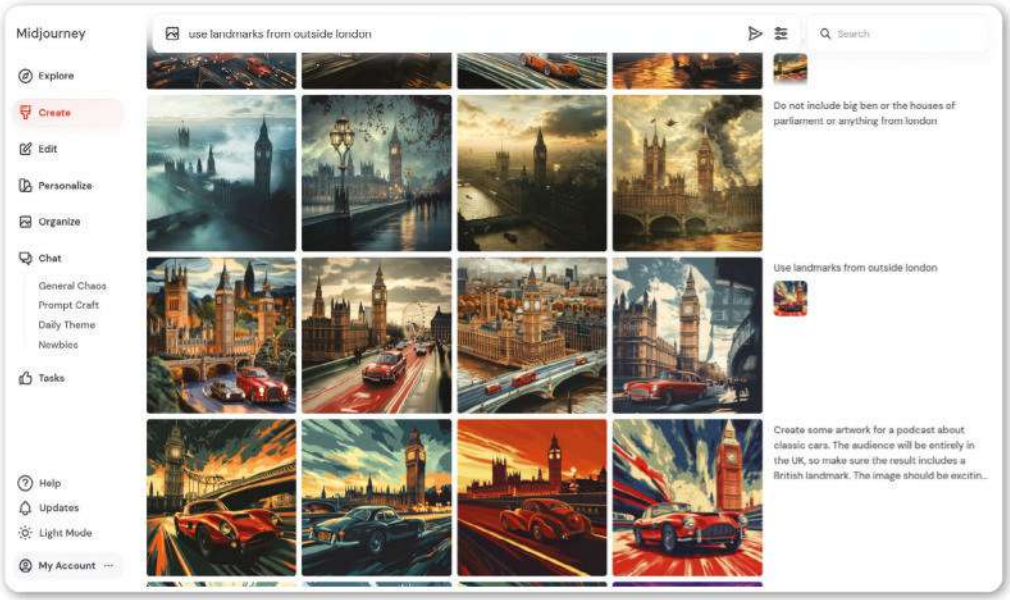
MIDJOURNEY

PROS Flexible generation prompting with direct access to parameters • basic in-browser editing • impressive external editor if you qualify to use it • mood boards and profiles

CONS Private image generation only available on Pro and Mega plans • some issues with text • external editor not available to all users

SCORE ★★★★★

PRICE From $10 to $120 per month from midjourney.com



Midjourney bills itself as an "open community", by which it means that other users can see your output and remix it for their own purposes. To generate private images, you'll need to subscribe to at least the Pro or Mega plans, at $60 and $120 per month respectively. Like all other plans, these rates are cut by 20% if you sign on for a year; whichever plan you're on, committing to a year also unlocks the option to upload images to use as a starting point for onward generation. On the monthly plan, only images generated by Midjourney itself can be used this way.

You can prompt via Discord or, as we did, through the Midjourney site. Adding parameters to your prompt, such as '--stylize', '--weird', or '--chaos', followed by a value, implements settings at the point of generation without you touching the built-in adjustment sliders. By default, images are generated using a global profile unless you create a more specific profile to guide the style of its output, initially by selecting which of two images you prefer from 40 pairs. You can also generate mood boards by uploading images that you like or find inspiring, and attach these to specific prompts.

Whichever option you choose will generate four images as starting points. Opening one of the sample images lets you upscale it, edit it, re-run the generation, use it as the starting point for a subtle or strong variation, or copy its style for use in another image. You can also enable pan and zoom controls. The former of these is particularly interesting, as it gives you the option to generate additional pixels beyond the top or bottom or either side of the selected image, which is great if it needs to fit a greetings card template or image frame on a page. It also lets you creatively crop an image to reposition the subject.

If you don't make any changes, images are square by default, but you can adjust the ratio on a stepped scale from 1:2 to 2:1 (width:height in each instance). You can also control the stylisation, weirdness and variety of the results, and the speed at which they're generated. You should take note of this option, as your GPU usage is capped according to the tier. On the basic plan, for example, you get three hours and 20 minutes a month of fast GPU time, but no "relaxed" GPU time. On Standard, which is three times the price, you get 15 hours a month of fast GPU time, and an unlimited amount of "relaxed" GPU time. Relaxed means you have to wait for a GPU to become available.

If the basic edits available through the preview screen don't go far enough, you can use a more powerful browser-based editor – with caveats. This is only available if you've run a minimum of 10,000 image jobs, you have a yearly membership or you've subscribed for a minimum of 12 months. But it's worth the commitment. This is a powerful tool that lets you go beyond tweaking what Midjourney itself has generated; for example, you could upload a picture of a family member, erase the jumper they were wearing, and prompt for a dinner jacket in its place. Midjourney would fill in the blank without touching the rest of your photo.

ABOVE Each prompt generates four images as starting points for refinements

BELOW Generating a profile lets Midjourney tailor its output to your tastes

PC PRO LABS WINNER

The ability to tailor the output by creating a profile, and to balance elements in the prompt using parameters, is impressive

Image generation results

Midjourney did well at photorealistic images, particularly a Venetian cat and a Vermeer-inspired oil painting, although the latter ignored the requested portrait orientation and the cat wasn't cleaning itself in any of the initial four passes. The 1980s disco poster captured the era's neon aesthetic, but initial renders had anatomical issues, including a claw hand, random leg and a half-teen/half-computer cyborg. We were very impressed by the pencil sketches, which were loose and demonstrated the kind of on-paper corrections you'd expect from a confident artist.

The podcast artwork featured London landmarks and a classic car, conveyed speed and used Union flag colours, but it had trouble incorporating landmarks from outside the capital. Even when we specified Edinburgh as a setting it included three Big Bens in the results.

The logo successfully included kittens and French flag colours, with one attempt at "chaton", although it did look more like "gyatton". Likewise, its two attempts to include our podcast name – Bonnet Banter – in the cover artwork delivered "Boner" and "Boon Tanter". No comment.

While the podcast artwork and 1980s poster had issues, and text rendering proved a challenge, Midjourney's image generation was impressive. The ability to tailor the output by creating a profile, and to balance elements in the prompt using parameters, is outstanding. Our only wish is the option to create private images on a cheaper plan.

OPENAI DALL-E

PROS Collaborative workflow • good text handling • smart when interpreting feedback

CONS Limited free allowance • reluctance to take inspiration from pop culture references

SCORE ★★★★½

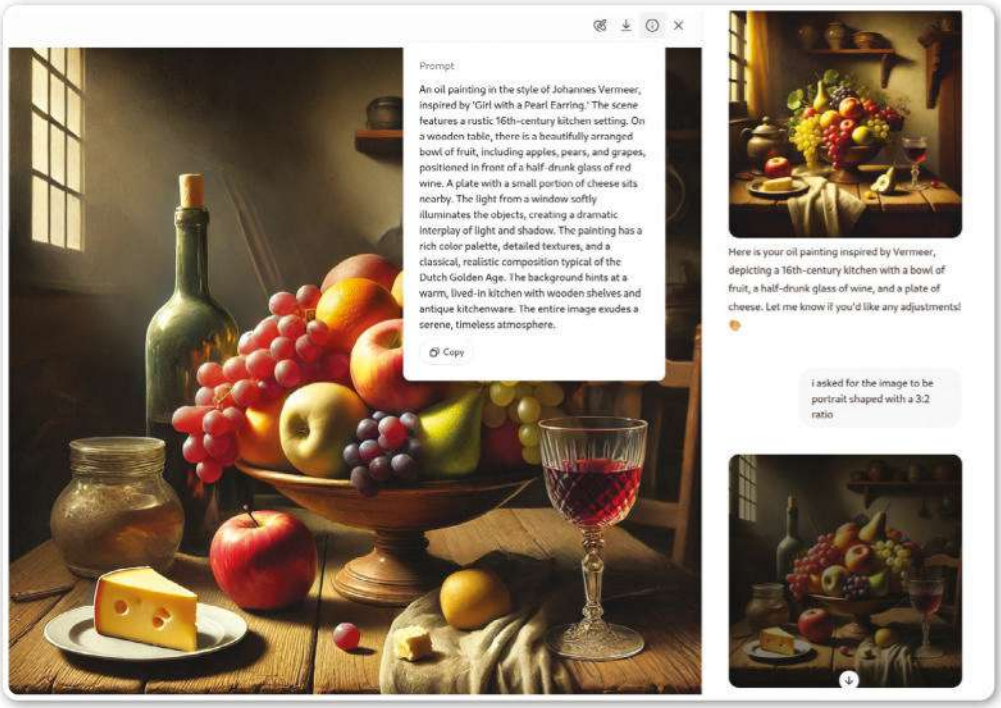
PRICE From free to $200 per month from chatgpt.com

DALL-E is accessed through the same interface as ChatGPT. The exact number of images you can generate is ambiguous, with ChatGPT explaining that free account users "typically get a limited number" of generations per month according to OpenAI's policies. The number isn't always fixed, and "may reset monthly or be subject to tiers. Paid users... often get more generation".

We managed to generate three free images before we had to pay for an upgrade, which isn't exactly generous. Moreover, it generated only a single image in response to each prompt, where Midjourney, Google ImageFX and Microsoft Designer generated up to four (and on one occasion, with Designer, seven). ChatGPT Plus, which is the cheapest paid tier, costs $20 a month plus VAT and offers "extended limits" on image generation, although again the cap isn't revealed. There's no option for annual billing. You can switch between ChatGPT's various models, but it recommends using GPT-4o as it provides better image quality, sharper details and improved text rendering. Other models, such as GPT-4-turbo, are optimised for speed and cost.

As you're interacting via the ChatGPT message box, the process is familiar, free-form and highly collaborative. Case in point: the first result in the canal-side cat test was good, but the colours were a little garish. We asked "can you make it more realistic" and it toned them down. However, when we asked it to "extend the picture to left and right", the cat and all the buildings around it changed, so it failed to extend an image we were otherwise happy with.

Otherwise, DALL-E is skilled at interpreting feedback. The first three pencil sketches looked too much like filters on photos, so we told it to "make it look like the artist only had two minutes to complete the sketch" and got an expressive result with much more life and artistic humanity.


Prompt
An oil painting in the style of Johannes Vermeer, inspired by 'Girl with a Pearl Earring.' The scene features a rustic 16th-century kitchen setting. On a wooden table, there is a beautifully arranged bowl of fruit, including apples, pears, and grapes, positioned in front of a half-drunk glass of red wine. A plate with a small portion of cheese sits nearby. The light from a window softly illuminates the objects, creating a dramatic interplay of light and shadow. The painting has a rich color palette, detailed textures, and a classical, realistic composition typical of the Dutch Golden Age. The background hints at a warm, lived-in kitchen with wooden shelves and antique kitchenware. The entire image exudes a serene, timeless atmosphere.
Copy
Here is your oil painting inspired by Vermeer, depicting a 16th-century kitchen with a bowl of fruit, a half-drunk glass of wine, and a plate of cheese. Let me know if you'd like any adjustments!
i asked for the image to be portrait shaped with a 3:2 ratio

If you're generally happy with an image but want to tweak a small area, you can mark it out for editing by painting over that area and typing a new prompt. At one point, we overpainted Big Ben in a picture that was otherwise Edinburgh and reminded DALL-E that we'd previously told it to get rid of all London landmarks. Within a few seconds, Big Ben had disappeared. Likewise, when it erroneously spelled our podcast Bounnet Banter after we'd made several changes, we only needed to tell it "the title is not spelled correctly" and it removed the spurious "u".

Image generation results

Like every other model, DALL-E ignored the portrait-orientation requirement in our Vermeer prompt, and produced a square image. When we followed up with "I asked for the image to be portrait shaped with a 3:2 ratio", it generated a new, square image with less realistic lighting. The level of detail in both was excellent, but they looked more like animation stills than oil paintings.

It refused to generate our 1980s poster artwork because "the request didn't follow content policy guidelines". When we asked for clarification it said it was "likely" that specific film titles tripped the filter, as "AI models are designed to avoid generating images that could directly reference or replicate protected intellectual property". It rewrote our prompt to comply with the guidelines, then produced a neon-rich artwork that certainly captured the spirit of the 80s. "1880s" according to the embedded text.

ABOVE Click the "i" above an image and you can see how DALL-E has reinterpreted your prompt

PC PRO RECOMMENDED

Its ability to understand oblique corrections was impressive, allowing us to adopt an expressive attitude when giving feedback

This lost century aside, it generally did well with text, usually spelling our podcast title correctly, and putting recognisable numbers and digits on the car number-plate in its artwork. The UK landmarks it selected were Big Ben, St Paul's Cathedral, a red London bus and Tower Bridge. We asked it to try again without using London landmarks, so it included Edinburgh Castle, what looked like some kind of pit lift made of cobwebs, and Big Ben. Later attempts included Stonehenge and the White Cliffs of Diver.

The only time it produced more than one image for an opening prompt was when it rendered our logo in three colourways, and correctly included a picture of a kitten. You can force multiple attempts by asking it to provide a set number of variations for you to choose from.

DALL-E's collaborative workflow feels natural, and although it initially generates fewer images than, say, Midjourney, the conversational process meant it ultimately took us no longer to arrive at an acceptable result. Its ability to understand oblique corrections was impressive, allowing us to adopt an expressive attitude when giving feedback that saved us from rethinking the prompt from scratch for each iteration.

BELOW Prompts and feedback develop as a natural conversation

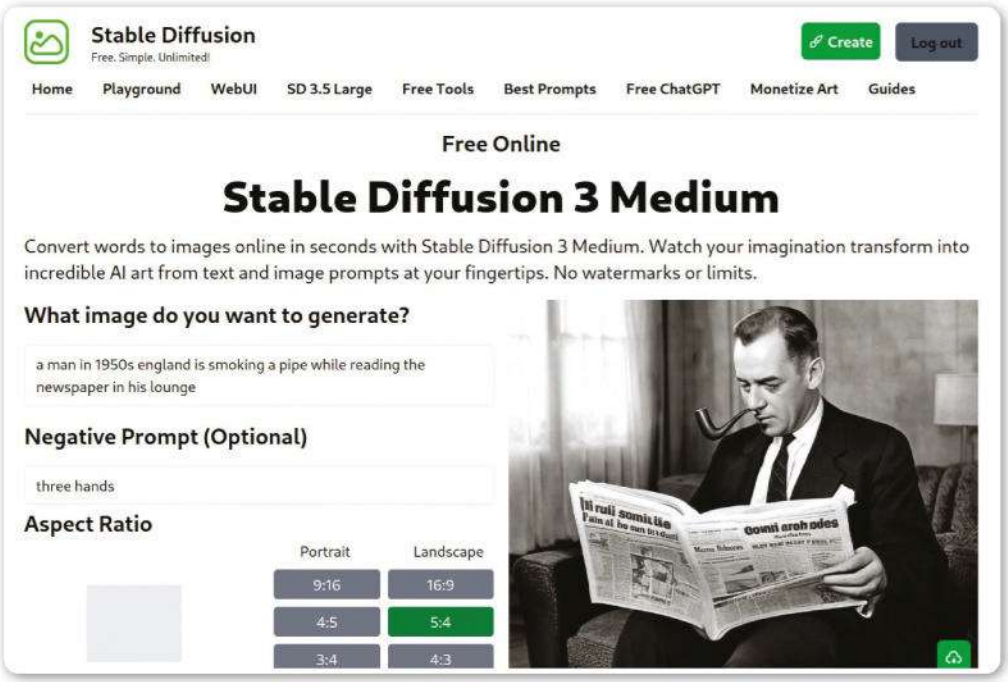
STABLE DIFFUSION

PROS Free to use • option to install on your own hardware • good human image generation

CONS Proved difficult to force some changes in a few models • challenging to use previous output within subsequent prompts

SCORE ★★★★☆

PRICE Free from stablediffusion.com



You can download and run Stable Diffusion on your own machine. A decent GPU will help it run more quickly, but it will work with onboard graphics if you're prepared to wait. Or you can use the hosted service, as we did in our tests.

There are several models to choose from, with more complex options generally taking longer to output an image. The wait is worth it. The quick web UI accurately produced a picture of a cat beside a Venetian canal, but the colours were oversaturated, and attempts to improve them by tweaking the prompt made little difference. It did give us a good collection of felines in the process, although one had a human hand and one had five paws.

Switching to the Stable Diffusion 3.5 Large model slowed things down but the results were closer to what we were after. The colours looked more natural while the water was among the best on test. However, it sometimes threw up a capacity error, warning that demand was high and suggesting we try later or switch to a less demanding model.

Behind the scenes, every image starts as a field of random noise, which Stable Diffusion refines over several passes, known as inference steps, until it arrives at the picture you've requested. By default, it runs through 40 steps when using the 3.5 Large model, and although you can increase this to a maximum of 50, you won't necessarily notice an improvement; by the time you get towards the upper limit you should already have a decent output.

You can specify the picture proportions when prompting by clicking preset buttons and, as with the other models on test, these outranked any mention of orientation in the prompt itself. You can specify how much weight it puts on guidance, the number of inference steps it works through and the starting seed. Changing the latter (on a scale of 0 to 2.14bn) will force it to generate different results, which we found useful when generating logos with the Stable Diffusion 3.5 Large model.

At other times, though, we had trouble forcing it to rethink an initial creation, even when adjusting the seed. With DALL-E, we'd been able to give casual feedback that it would take into account, but that didn't prove possible here. When we first received an oversaturated Venetian scene, for example, we clicked the Remix button and told it to tone down the colours. The result was a picture of a tree-covered hillside.

ABOVE Stable Diffusion did a good job of generating images of people

Image generation results

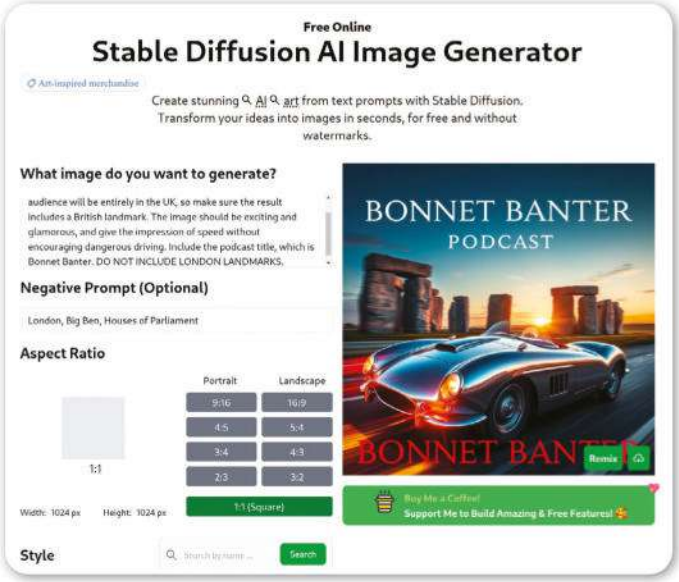
Stable Diffusion's output was often very good but, with the caveat that judging images is subjective, we frequently preferred what we saw from other services on test.

Stable Diffusion's output was often very good, but we frequently preferred what we saw from other services on test

Our pencil sketches didn't have the character of those produced by Midjourney or DALL-E (after we'd told the latter to imagine that the artist had been rushed). In a couple of examples, Stable Diffusion also included 2D buses in the results, which had height and length but no depth. As they were face-on, this was quite obvious.

Where it did well was in text generation. Most characters included in the artwork were accurately rendered, and large text objects generally made sense. Spelling Banter with a double "T" and duplicating the word Bonnet in our podcast artwork was one unfortunate slip-up in this respect. As with the other services on test, Stable Diffusion initially defaulted to London when including landmarks in the artwork, but when we added "do not include any London landmarks" to the prompt it swapped them out for Stonehenge to produce a piece of attractive, clear and photorealistic artwork.

BELOW When we asked for non-London landmarks, it settled on Stonehenge


Free Online
Stable Diffusion AI Image Generator
Create stunning AI art from text prompts with Stable Diffusion. Transform your ideas into images in seconds, for free and without watermarks.
What image do you want to generate?
audience will be entirely in the UK, so make sure the result includes a British landmark. The image should be exciting and glamorous, and give the impression of speed without encouraging dangerous driving. Include the podcast title, which is Bonnet Banter. DO NOT INCLUDE LONDON LANDMARKS.
Negative Prompt (Optional)
London, Big Ben, Houses of Parliament
Aspect Ratio
Portrait
Landscape
9:16
16:9
4:5
5:4
3:4
4:3
2:3
3:2
1:1
1:1 (Square)
Width: 1024 px
Height: 1024 px
Style
Search
BONNET BANTER
PODCAST
Support Me to Build Amazing & Free Features!

Although we didn't find it as easy to direct as some other generators, we did feel that the effort we put in to working with Stable Diffusion was repaid – and, although it wasn't part of our core tests, we found it particularly adept when it came to generating humans in realistic surroundings. The experience is less collaborative than working with Midjourney or DALL-E, but the fact you can access it for free makes it well worth checking out for fun.

Photorealistic images

PROMPT

"Make a photorealistic image of a ginger cat sitting on the side of a canal in Venice. The cat is cleaning itself while a gondola passes by in the background. On the other side of the canal is a church with steps leading up to double doors, and a dome on top. The weather is sunny."

GOOGLE IMAGEFX

ImageFX's cat was a triumph. The animal and its surroundings were convincing, while the lighting and colours were spot on. The other cats that it generated had too many paws.

ARTBREEDER

None of Artbreeder's cats were cleaning themselves, and although one of its other images was a sharper rendition of Venice, this is the best-generated animal.

ADOBE FIREFLY

The water and foreground are well rendered here, but we weren't entirely convinced by Firefly's buildings in this Venetian scene.

LEONARDO

Although Leonardo's Classic View cats were cleaning themselves, this feline, from the Creative Flow mode, was more convincingly rendered.

OPENAI DALL-E

Although a little game-like, this image is packed with detail. Reflections, stone grain and weed are well handled, although the gondolier may be a little mis-proportioned.

MIDJOURNEY

The shallow depth of field contributes to the realism of Midjourney's response. The lighting on the wet steps is also impressive.

STABLE DIFFUSION

Realistic brick and stonework, and good water from Stable Diffusion. Further tests involving cats on beaches produced better results than this.

MICROSOFT DESIGNER

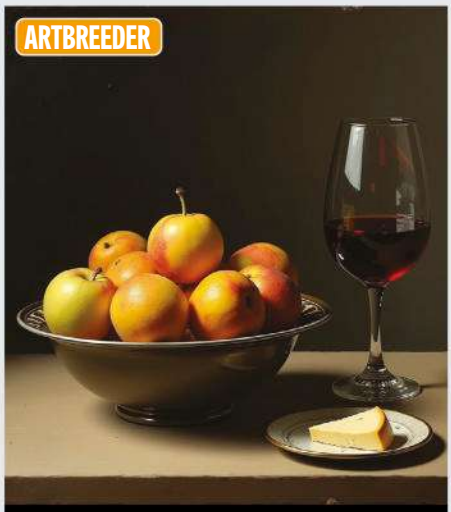
An attractive composition, an attractive cat and a detailed background make for a good image overall, although it's not as convincing as ImageFX.

Oil painting

PROMPT

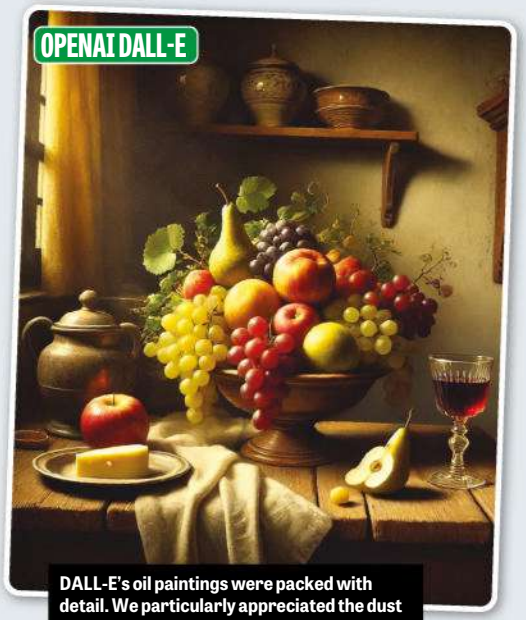
"Generate an oil painting. The subject is a bowl of fruit in front of a half-drunk glass of wine. It is in a kitchen some time in the 16th century. On the same table as the bowl of fruit there is a plate with a little cheese on it. Use Vermeer's *Girl with a Pearl Earring* as your inspiration. Make the picture portrait shaped in 3:2 ratio."

ARTBREEDER



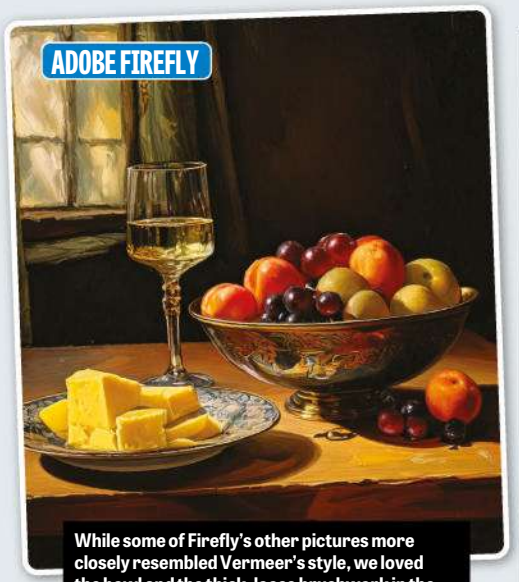
Beautiful natural tones, well balanced lighting and, if you look closely, a battered canvas. A very pleasing result.

OPENAI DALL-E



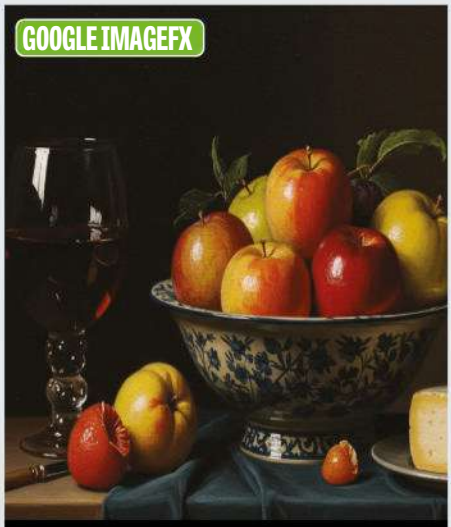
DALL-E's oil paintings were packed with detail. We particularly appreciated the dust on the copper urn in this render.

ADOBE FIREFLY



While some of Firefly's other pictures more closely resembled Vermeer's style, we loved the bowl and the thick, loose brushwork in the background of this painting.

GOOGLE IMAGEFX

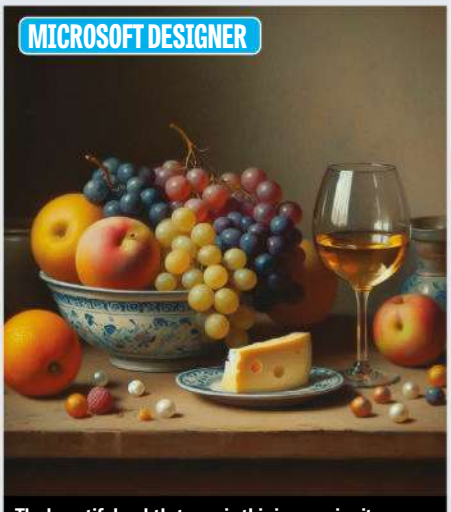


There's some brilliant subtlety to the darker tones in this image, and the reflection in the glass is impressive.

LEONARDO

The way that the light catches the paintwork in the upper left quadrant makes this look like a photo of a painting in a gallery.

MICROSOFT DESIGNER

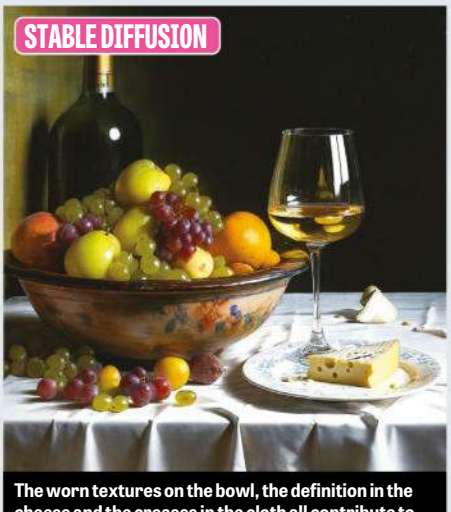


The beautiful, subtle tones in this image give it an authentic feel. You can almost feel the mould and the dust on those grapes.

MIDJOURNEY

The fabric is beautifully rendered here. So is the canvas texture, which is particularly clear where an external light source catches it at the top of the frame.

STABLE DIFFUSION



The worn textures on the bowl, the definition in the cheese and the creases in the cloth all contribute to the realism here. The foot of the glass was an unfortunate slip up.

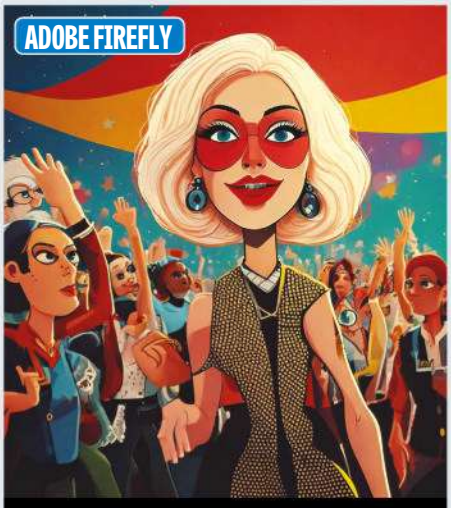
Poster art

PROMPT

"Make an advertisement for a 1980s-themed disco at the local village hall. Include cartoon people dressed up in clothing from that time, and use films like *Back to the Future*, *ET* and *The Goonies* as your inspiration."

You can't get much more 80s than this artwork from ImageFX, which is packed with colours, fonts and imagery from that decade.

Artbreeder's posters were not only packed with 80s fashion; they also had a faded retro vibe.



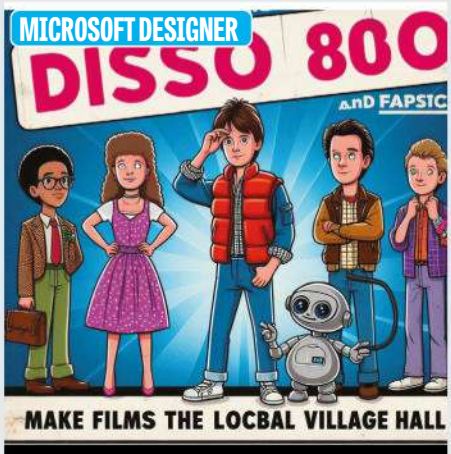
While there are a few strange faces here, we actually think they contribute to the overall vibe of this fun-filled poster artwork.

The space-age disco vibe is strong in this artwork from Leonardo, with well-proportioned subjects, bright colours and plenty of 80s references.

Cassettes, jukeboxes, turn-ups... plenty of 80s cues here and, as with the other models, a lot of neon colours.

DALL-E's poster art leaned heavily on the request for "cartoon people" in our prompt, with eye-catching neons that really popped.

Midjourney's poster art was full of life but there were occasional anomalies, such as the cyborg leg in this image, and a half boy/half computer elsewhere.



Microsoft Designer's artwork was bold but, as was the case with the images generated by some other models, the words will need some editing.

Pencil sketch

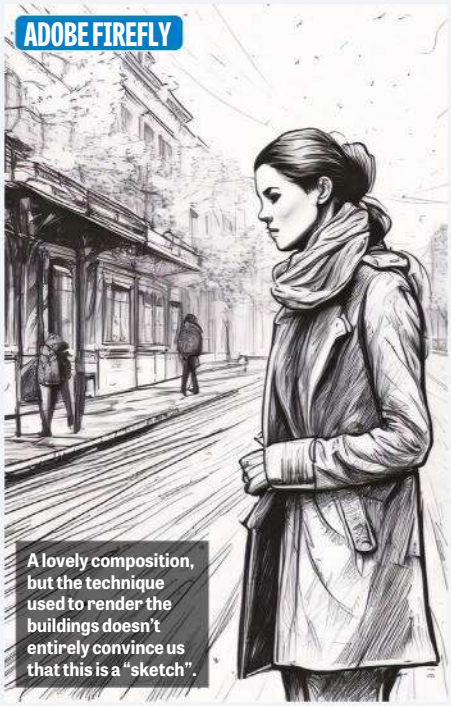
PROMPT

"A pencil sketch of a woman waiting for a bus. It is raining and the bus is running late."

ARTBREEDER

Artbreeder's initial sketches were beautiful and precise. When we asked it to imagine the artist was rushed, it produced more expressive work, like this.

ADOBE FIREFLY



A lovely composition, but the technique used to render the buildings doesn't entirely convince us that this is a "sketch".

MIDJOURNEY

Midjourney produced our favourite "sketch". It was subtle and naturalistic, and looked like it had been quickly dashed off as the bus approached.

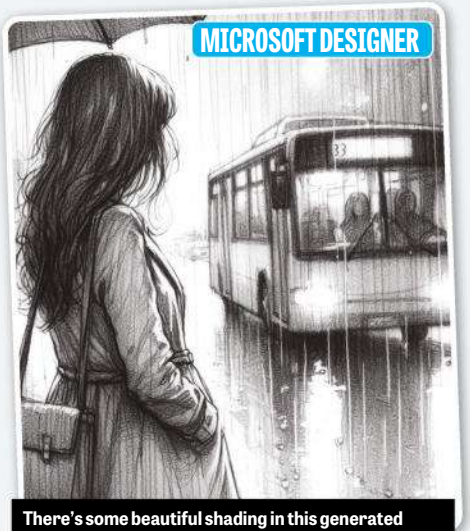
GOOGLE IMAGEFX

While it's not to our taste, some of the childish sketches that ImageFX produced conformed precisely to the brief.

LEONARDO

Leonardo's pencil sketches were beautiful but very detailed, even after we'd asked it to reduce detail and imagine the artist only had 60 seconds.

MICROSOFT DESIGNER



There's some beautiful shading in this generated pencil sketch from Microsoft Designer, although we would have preferred a more rushed result.

OPENAI DALL-E

A wonderful loose sketch from DALL-E after we'd asked it to imagine the artist had only 60 seconds to complete the picture.

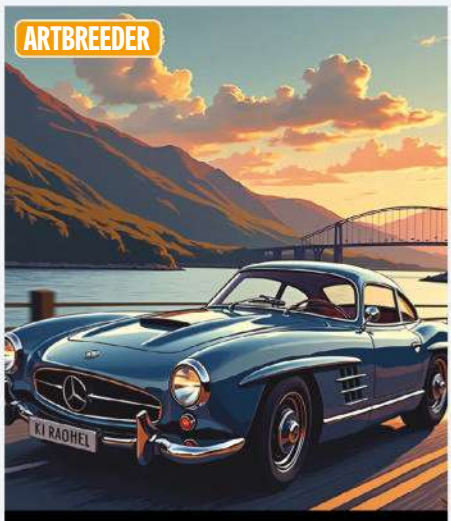
STABLE DIFFUSION

A two-dimensional bus in this sketch from Stable Diffusion. We liked the natural shading, though, and the inclusion of a signature.

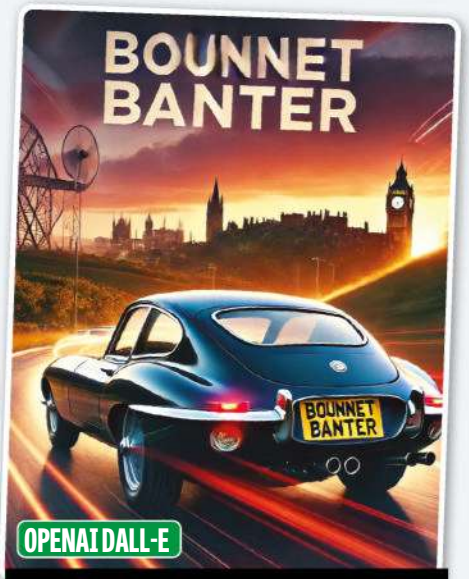
Podcast cover art

PROMPT

"Create some artwork for a podcast about classic cars. The audience will be entirely in the UK, so make sure the result includes a British landmark. The image should be exciting and glamorous, and give the impression of speed without encouraging dangerous driving. Include the podcast title, which is Bonnet Banter."



Although this didn't include our podcast title, where a few others from Artbreeder did, the landscape could be said to resemble the Highlands.



One of several iterations from DALL-E included strange pit-head machinery, which we later removed using the selection tool.

Although there's an architectural quirk here, which didn't appear in other Midjourney pictures, we love the impression of speed this piece conveys.

This, from ImageFX, could well be a photo, and the podcast title is both cleanly rendered and spelled correctly.

While beautifully rendered, Leonardo's responses to our prompt less successfully gave an impression of speed.

Great car, grass and landscape, and although the composition is similar, the building thankfully isn't Big Ben or the Houses of Parliament.

Union flags, a fast car and microphones – Microsoft Designer hit all the bases here. Just a shame about the spelling mistake.

An attractive car, speed, clear wording and a recognisable non-London landmark from Stable Diffusion.

Logo

PROMPT

"Create a two-colour logo on a white background inspired by the French word 'chaton'. That word must appear in the logo."

GOOGLE IMAGEFX

Clean, simple and easily reproduced at a range of sizes, this two-tone logo from ImageFX is as neat as a pin. It didn't need the circumflex accent, though.

STABLE DIFFUSION

A clever interpretation from Stable Diffusion, in which the two peaks could be cats' ears.

LEONARDO

One of several beautiful logos from Leonardo, each correctly featuring cats or kittens, but not always our brand name.

OPENAI DALL-E

DALL-E produced a cute, well-spelled logo that would reproduce at a variety of sizes.

MICROSOFT DESIGNER

Although Microsoft Designer also produced a more appropriate red, white and blue logo, the cat treatment is more striking in this example.

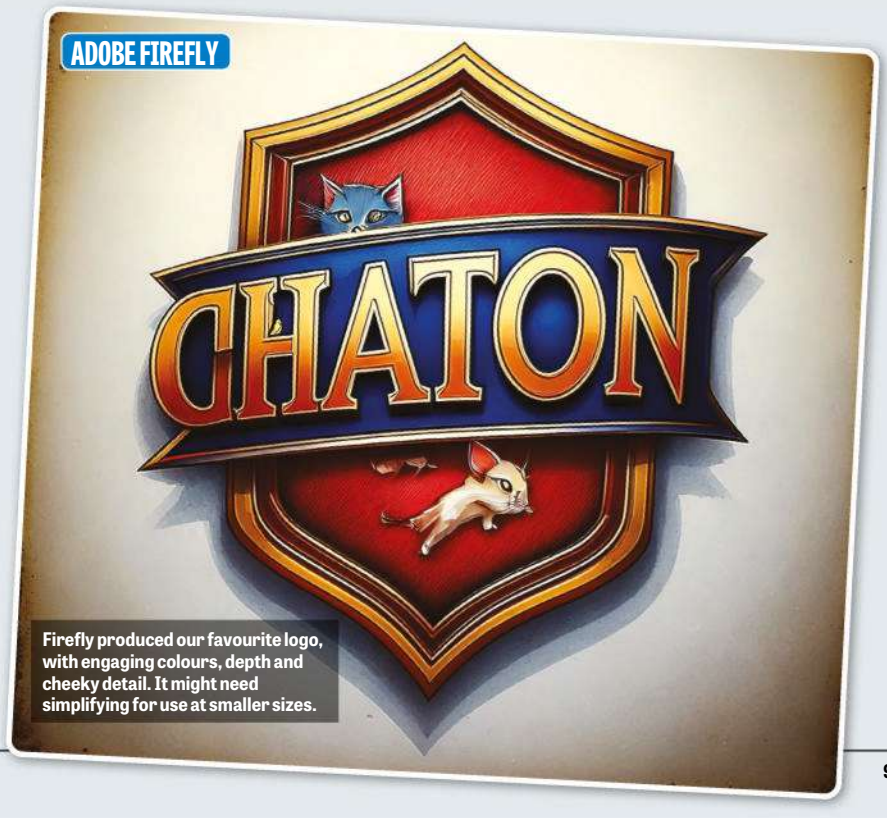
MIDJOURNEY

An elegant interpretation from Midjourney that would reduce well, but it's missing our brand name.

ARTBREEDER

Some of Artbreeder's other logos were text-centric, but this example is more eye-catching.

ADOBE FIREFLY



Firefly produced our favourite logo, with engaging colours, depth and cheeky detail. It might need simplifying for use at smaller sizes.

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AI and the artist

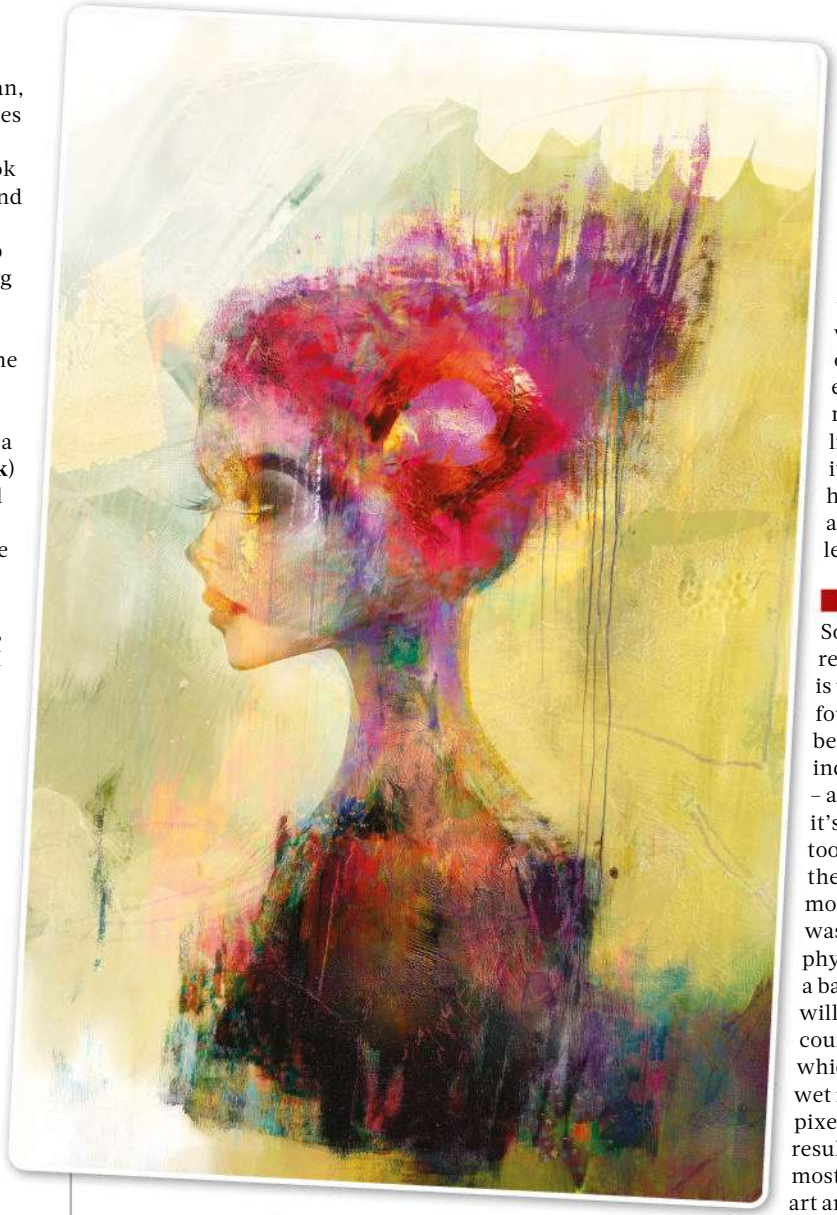
Curious about the intersection of technology and creativity? So is JAG Gillan, a pioneering digital artist who blends AI with traditional art techniques

"I remember when the *Telegraph* opened its photo library," JAG Gillan, a pioneering digital artist who uses AI in his practice, told *PC Pro*. "I would go to their office and look through hundreds of negatives and slides, and even that was seen as doing a photographer out of a job because we were using something that already existed."

We'd met to discuss his approach to Midjourney, which he uses in creating what he calls Organic Electronic Art: digital pieces that appear untouched by a computer. His work (**jagart.co.uk**) is defined by thick, expressive oil strokes, fluid watercolours and the subtle imperfections that give art a human touch. On countless layers, each created by hand in Rebelle, a digital painting studio, they surround and overlay the AI element that inspires each piece. Naturally, our conversation had turned to a topic weighing on many artists' minds: how AI draws from publicly accessible images and the concern that it could even displace the creators it learns from.

Gillan acknowledges this possibility, but points out that we've seen something similar before.

"When the Mac came out and you got DTP, the bosses went to the secretaries, you've got a Mac now – you can create something. And somebody did create something, but realistically it looked like it was done on a computer. There was no soul to it; no design thought… and now, in a similar way, it's so easy to go in and make an image with AI that looks like rubbish."



ABOVE **In creating *Vivid Dreams*, Gillan prompted Midjourney for a silhouette, which formed the basis of a hand-crafted artwork produced in Rebelle 7**

Part of the process

And this is an important distinction. The longer he's worked with AI – and Midjourney in particular – the less Gillan finds he relies on it. Today, the AI element, while important, is just a small part of each image.

"I can ask AI, can I have a face? Give me a head and shoulders or somebody melancholy or happy… and that's my starting point. Then I have to apply everything else – my emotions – to that face. So AI has accelerated the process. I don't have to photograph a face or get something from iStock, and I can get closer to what I want than I could do with photography. If I want it to be surreal, I can, and I allow AI to give me long necks, which I love. People ask why the women I create have always got long necks, but that's the way it came out. It's the imperfectness of it. I love that long neck. I can work with it. For me, it looks elegant. And that's lovely. It was a happy accident."

But even those accidents don't come about by chance. No prompt has ever delivered something that Gillan has liked on the first run, so for him, prompting – like painting – is an iterative process. Indeed, this was one of the things that attracted him to Midjourney, which allows the user to embed pseudo codes in their prompts. Much like variables, these control the degree to which aspects within an input influence the output.

"There are style weights and chaos weights and numerous other variables," Gillan explained, "and the more you tell it what you like, the more accurate it gets. I've ranked hundreds of pictures, and through that, it's learned what I like."

"What people need to focus on now is how we use this for good, to make our processes better, and to become better artists for it"

Personal style

So the way Midjourney responds to Gillan's input is unique. It's like a fountain pen nib that has bent to accommodate his individual writing style – and, in that respect, it's as much of a creative tool as Photoshop's pencil, the eraser in GIMP or, more pertinently, the wash with which a physical artist might prime a bare canvas. The output will be subsumed beneath countless layers, each of which is laid down using wet media tools in a dry, pixel environment. The result looks nothing like most people's concept of AI art and, when hanging in a gallery, Gillan's work is hard to distinguish from that created using oil or acrylics.

Despite this, there are still some who feel that his use of AI taints the work, even if they'd taken it at face value before he'd explained his creative process. But, as he says, "the genie is out of the bottle", and he's hopeful that, given time, AI will be seen as an aid for upcoming artists.

"You either pivot and learn to work with it, or you don't," he said. "It's not a short-circuit, but if you use it to speed up your work, that's got to be a good thing. I can't help the fact that it's there. What people need to focus on now is how we use this for good, to make our processes better, and to become better artists for it."

Buyer's guide

NAS appliances 2025

Buy the right NAS drive and you can not only save on monthly storage subscription costs but roll out new features, too. Dave Mitchell explains what to look for

Many SMBs facing a storage crisis have turned to the cloud, but as the monthly bills keep rolling in some are finding these services are an increasingly expensive solution. Network-attached storage (NAS) appliances can be a far more cost-effective option as although their initial outlay will be much higher, ongoing costs are negligible.

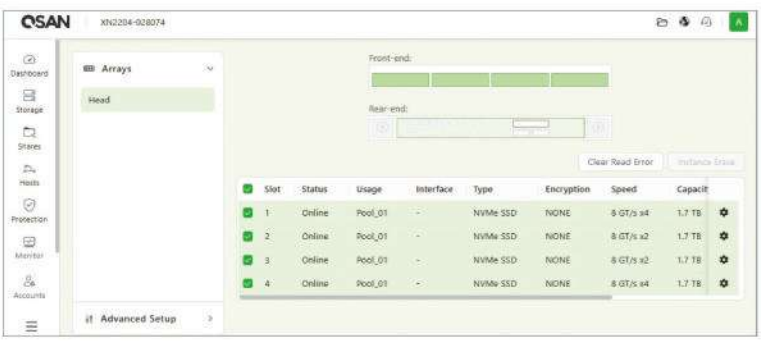
NAS appliances can also be a much better choice than a purpose-built server. There's no need to worry about the additional costs of an operating system and client access licences as NAS systems are supplied with a business-class OS, can serve as many users as you want without paying extra – and come with free business apps including backup, replication and much more.

The benefits of NAS are manifold: they're easy to deploy, simple to manage and their storage capacity can be swiftly expanded in step with demand. Keeping primary storage on premises means it won't be impacted by cloud provider or internet outages, performance will be significantly faster than the cloud and data security is easier to maintain as you have total control over all access.

The good news for SMBs is that there are plenty of NAS appliances to choose from, with capacities to match every demand and prices for every pocket. This month, we test business-class desktop and rack models from Qsan, Synology, TerraMaster and Ugreen and put them through their paces in the lab to help you choose the right one.

Shapes and sizes

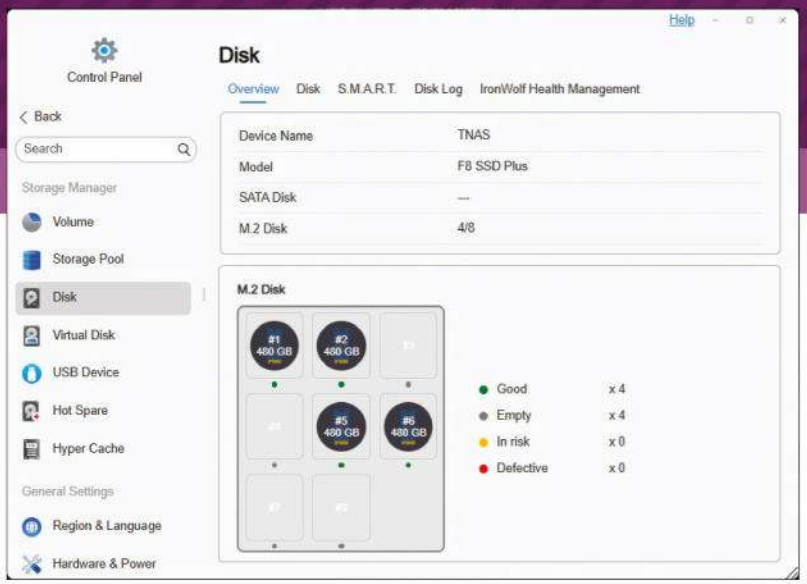
Your office setup and layout will determine whether a desktop or rack-mount NAS appliance is the best choice. In either case, it's important to select one that can satisfy your capacity requirements now and also well into the future. You'd be surprised at how quickly a NAS appliance can fill up with data, so you'll want one with a high capacity and plenty of expansion potential.

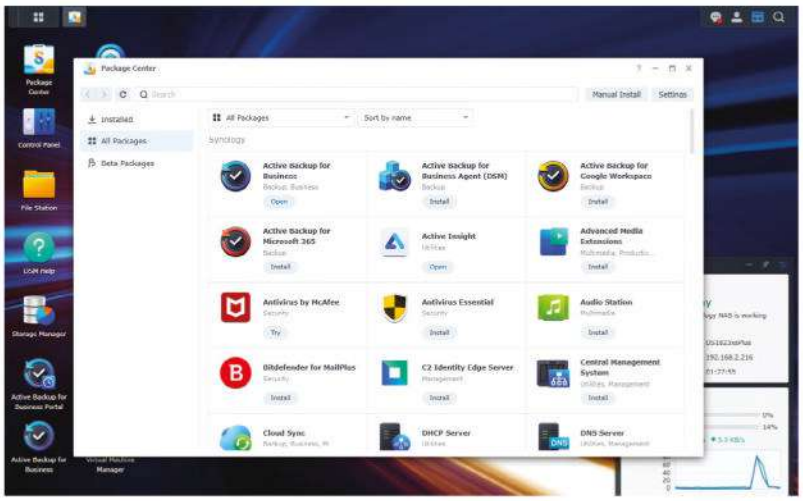


BELOW Qsan included four high-performance U.3 NVMe SSDs with its NAS appliance

Choose an appliance that leaves you with some spare drive bays or one that has the option to connect external expansion units so you can add extra drives and incorporate them into existing RAID arrays. Most NAS appliances let you individually swap out hard disks with larger ones, but the money spent on the original drives will be wasted and RAID array rebuilds can take a very long time.

You can buy unpopulated NAS appliances and fit your own drives, but avoid cheap desktop models as they aren't aimed at NAS appliance use. Choose NAS-specific SATA drives such as Western Digital's Red and Seagate's IronWolf models:





LEFT **TerraMaster's palm-sized NAS supports up to eight fast M.2 NVMe SSDs**

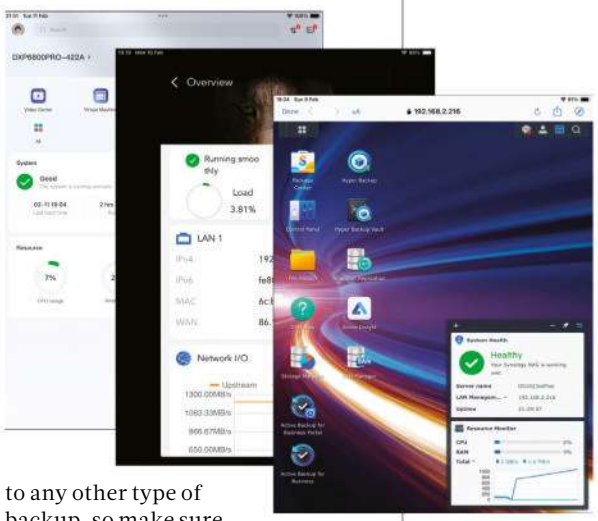
these are designed to work continuously in multi-drive NAS appliances and have built-in protection features such as vibration compensation technology. Note also that one vendor in this guide only permits its own brand of NAS drives to be used in its business appliances.

SATA SSDs are a popular addition to a NAS appliance. While capacities are much lower, they offer superior random write speeds to HDDs and can be added to an existing array as a performance-enhancing cache. For the latter, many NAS appliances feature dual internal M.2 NVMe SSD slots so you can cache in and save your main bays for general storage.

Data protection

Along with file-sharing services, many businesses will use a NAS as a destination for their server and workstation backups, but don't forget the NAS data itself will need protecting. RAID provides insurance against hard disk failures but it won't be a lot of use if your NAS dies, gets hacked or is stolen.

Apply the same protection strategy to your NAS as you would



ABOVE **Many vendors offer free mobile apps to monitor their appliances remotely**

to any other type of backup, so make sure its data is copied to an offsite location. Using cloud storage for NAS backups that could be many terabytes in size will be expensive, and a good alternative is to copy or replicate data to a remote appliance.

Many NAS vendors include free apps that run scheduled backups to remote systems, and built-in support for the industry-standard Rsync service allows you to transfer and synchronise data across different appliance brands. These processes can be bandwidth intensive and another option is block-level snapshot or volume replication where once the initial backup has completed, only changed blocks will be sent to the remote system.

NAS data needs to be protected from ransomware attacks, and a valuable ally is WORM (write once, read many). Look for features such as WriteOnce and HyperLock-WORM, which can turn selected NAS shares or volumes into immutable storage where, once data has been written to them, it can't be modified or deleted until the retention period you set has expired. Some offer a Compliance mode that stops data from ever being deleted.

"Many NAS appliances feature dual internal M.2 NVMe SSD slots so you can cache in and save your main bays for general storage"

LEFT **Synology offers an impressive range of free business apps**

Speed demons

The latest business NAS appliances are equipped with fast, multicore CPUs that are quite capable of handling the demands of backup and file-sharing activities. A base system memory of 8GB will be enough for these tasks, but ensure you can upgrade this as many NAS features and apps will require more.

The range of apps available for NAS appliances makes them highly versatile, but the more you load on them the more your memory requirements will increase. Virtual machine (VM) manager apps are particularly resource-hungry, so if you plan on turning your NAS into a virtualisation host, factor the number of VMs you require into your CPU core and memory calculations.

Once you start serving up storage to multiple users and using the appliance as a backup destination, ensure that it has enough network bandwidth to cope. All business NAS appliances come with gigabit ports as standard, with many now including 2.5GbE multi-gigabit ports, but if your need for speed is greater, choose an appliance that has integral 10-gigabit (10GbE) ports or spare PCIe slots for additional 10GbE adapter cards.

Intense competition in the NAS market is keeping prices down while features keep getting better. The four appliances on review offer a wide range of features with performance to match, so read on to see which one suits your business best.

Qsan XCubeNAS XN2204-4C

A low-profile hybrid storage appliance with excellent performance and impressive hardware at a great price

SCORE ★★★★½

PRICE As reviewed, £3,072 exc VAT (MSRP) from servercase.com

Qsan's XCubeNAS XN2204-4C is a hybrid appliance that aims to deliver affordable all-flash storage to SMBs. Don't be deceived by its modest dimensions; this 1U rack appliance is bursting with features.

Up front there are four universal LFF/SFF drive bays that support standard SATA HDDs or SSDs and NVMe SSDs. Qsan offers a tempting proposition when it comes to value, with the price we've shown including four 1.92TB U.3 NVMe SSDs.

The appliance also has two internal M.2 NVMe SSD slots, which can be used as a mirrored cache or standard storage pool. Networking options look good, too: it sports four 2.5GbE multi-gigabit ports and teams them up with quad 10GbE SFP+ fibre ports, and the spare PCIe expansion slot accepts Qsan's optional 10GbE and 25GbE cards.

A quad-core 2GHz Intel Xeon D-1712TR CPU sits in the driving seat and is partnered by 8GB of DDR4 memory, which is upgradable to a hefty 256GB. Power redundancy is present, with the price including dual 450W hot-plug supplies.

Another appealing feature is its insane expansion potential. Add Qsan's optional SAS3 PCIe card and you can daisy-chain a mix of Qsan's XD5300 external disk shelves for a total of 414 drives and a maximum raw capacity of nearly 9PB.

The XN2204-4C is physically identical to Qsan's XN8104R model, but there are big differences in the software department. Qsan advised us that the XN8104R will continue to use its QSM 3 operating system (OS) while the XN2204-4C runs the updated QSM 4 which is also employed by its XCubeNXT dual controller appliances.

Deployment is swift. We used the QSM 4 wizard to choose drives, create standard storage pools or ones with deduplication and compression applied, select thick or thin provisioning, and enable pool encryption if self-encrypting drives are installed. With only four drive bays available, RAID options are limited; we chose a RAID5 array as the storage overheads of RAID6 makes this type less appealing.

When creating volumes, you choose the block option for IP SAN presentation or file volumes for NAS shares. Along with local user accounts, access security can be applied by creating hosts that define the network ports on which iSCSI targets and NAS shares will be presented.

ABOVE The modestly sized XN2204-4C offers huge potential for expansion

Snapshot protection can be applied to each volume and run manually or scheduled for as often as every five minutes. Essential ransomware protection is present as well; WORM (write once, ready many) can be applied to file volumes where you set a retention period in days, hours or minutes.

QSM 4 offers a modest selection of business apps. QReplica manages block level replication of SAN volumes to local storage or remote Qsan appliances, while the Rsync service supports client and server modes. Cloud backup services can currently use S3-compatible storage, with Amazon S3 and Microsoft Azure options under development, as is the integral Microsoft 365 email backup feature.

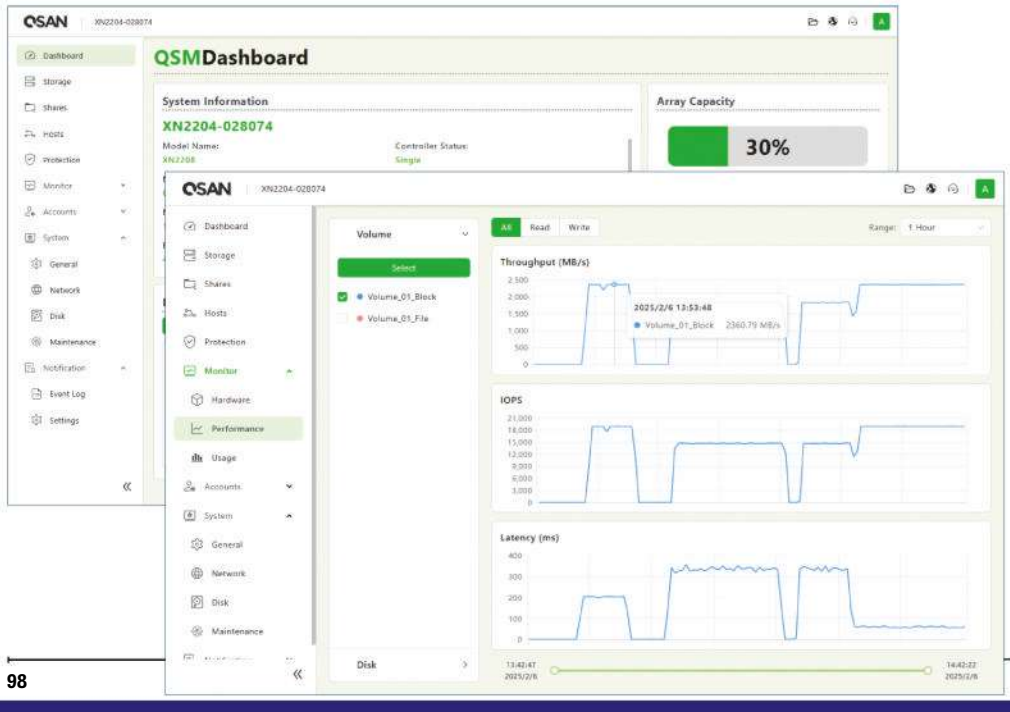
"Another appealing feature is its insane expansion potential. Add a PCIe card and you can daisy-chain a total of 414 drives"

The XN2204-4C posted some big numbers in our 10GbE performance tests. A share mapped to a Dell PowerEdge R760xs Windows Server 2022 host returned 9.1Gbits/sec and 9.2Gbits/sec for Iometer sequential reads and writes, while random operations delivered 8.9Gbits/sec and 9.3Gbits/sec.

IP SAN speeds are excellent, with a 1TB iSCSI target recording 9.2Gbits/sec across the board for sequential and random reads and writes. Ramping up the pressure with a dual 10GbE MPIO link to the target saw sequential reads and writes leap to 18.5Gbits/sec and 17.7Gbits/sec, while random operations mustered 18.4Gbits/sec and 14.4Gbits/sec.

The XCubeNAS XN2204-4C offers an incredible specification for the price, which includes a full house of U.3 NVMe SSDs. Business-focused apps are minimal, but it delivers impressive 10GbE performance together with a monumental storage expansion potential.

BELOW QSM 4 makes appliance management easy and performance is outstanding



SPECIFICATIONS

4-core 2GHz Intel Xeon D-1712TR processor • 8GB DDR4 RAM (max 256GB) • 4 x LFF/SFF SATA/NVMe hot-swap bays • 2 x M.2 NVMe slots • 4 x 1.92TB U.3 NVMe SSDs • 4 x 2.5GbE • 4 x 10GbE SFP+ • PCIe Gen4 x8 slot • 2 x 450W hot-plug PSUs • 3yr hardware warranty

Synology DiskStation DS1823xs+

A powerful desktop NAS with a high capacity, great data protection features and top 10GbE performance

SCORE ★★★★★

PRICE Diskless, £1,397 exc VAT from broadbandbuyer.com

The DiskStation DS1823xs+ may have been launched a couple of years ago but it still stands tall as one of Synology's flagship high-performance desktop models. Reasons are manifold: this 8-bay model is driven by a powerful quad-core 3.35GHz AMD Ryzen V1780B CPU, and its base 8GB of DDR4 ECC memory can be boosted to 32GB.

The main drive bays support SATA HDDs and SSDs, while the two internal M.2 NVMe SSD slots can be used as a performance-enhancing cache or a standard storage pool. Bear in mind that all storage devices are restricted to Synology's own models; it will work with drives from other manufacturers but Synology won't provide support if you use them.

Networking options are plentiful, with the appliance offering a 10GBase-T and two gigabit data ports, while management can be isolated on a separate gigabit port. The spare PCIe expansion slot offers plenty of upgrade options and supports Synology's own dual-port 10GbE and 25GbE cards.

Installation is a breeze. After loading four 4TB Synology HAT5300-4T HDDs, we used the quick-start wizard to deploy the latest DSM 7.2 software and create a RAID5 array. With the appliance hooked up to our 10GbE network, it delivered impressive performance.

A NAS share mapped to a Dell PowerEdge R760xs Windows Server 2022 host returned fast Iometer read and write speeds of 9.3Gbits/sec and 9.2Gbits/sec. Real-world numbers are good, with 25GB file copies between the server and appliance averaging read and write speeds both of 5.7Gbits/sec, while securing a 22.4GB test folder with 10,500 small files mustered 2.7Gbits/sec.

IP SAN performance is also impressive, with a 1TB iSCSI target mapped to the server delivering sequential read and write speeds of 9.3Gbits/sec and 9.1Gbits/sec. To test SSD caching, we fitted a couple of Synology's 800GB NVMe SSD sticks and assigned them as a mirrored read-write cache to our storage pool.

You won't see any significant improvements for sequential reads and writes, but they're a good investment if you have workloads generating a lot of random write operations. Without the cache we recorded Iometer random write speeds of 0.75Gbits/sec for our iSCSI target, which leapt to 6.1Gbits/sec with the cache assigned while IOPS went from 5,000 to 37,000.

DSM 7.2 is sharply focused on data security and ransomware protection: along with full volume and share encryption, it provides WORM (write once, read many) policies for NAS folders on Btrfs volumes. Coined WriteOnce, you select it during shared folder creation and choose Enterprise or Compliance policies that apply customisable file lock periods, enforce retention periods in days, years or forever, set files as immutable and stop storage pools, volumes and shared folders from being deleted.

The Snapshot Replication app manages NAS and IP SAN snapshots and offers fast rollback services along with NAS share file and folder recovery using the File Station app. It can also create immutable snapshots that can't be deleted by any method until their retention period has expired.

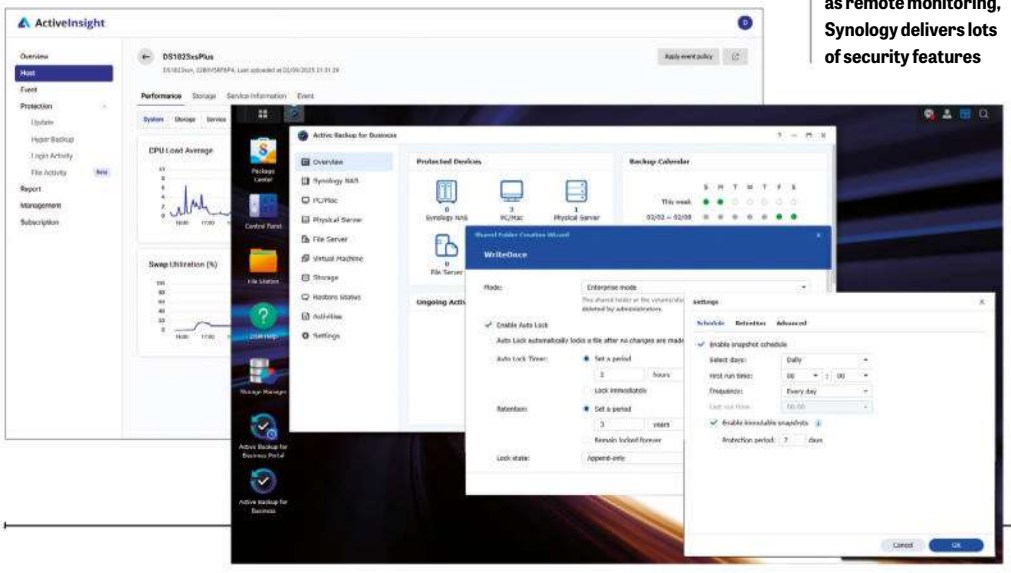
DSM 7.2 offers a wealth of business apps, a standout one being the Active Backup suite, which comprises three apps for securing servers, workstations, VMware and Hyper-V virtualised environments and remote Synology appliances, along with Google Workspace and Microsoft 365. The Hyper Backup app looks after local, remote, Rsync, cloud and iSCSI LUN backups while the Drive Server app provides sync services for file sharing and collaboration.

The DS1823xs+ may be an old-timer but it still cuts the mustard in the NAS stakes. Its powerful hardware delivers impeccable performance, it's packed to the gills with business apps and offers great data security measures.

ABOVE Synology's DS1823xs+ is powered by a quad-core AMD Ryzen V1780B CPU

PC PRO ★★★★★ A-LIST

"The DS1823xs+ may be an old-timer but it still cuts the mustard in the NAS stakes. Its powerful hardware delivers impeccable performance"



BELOW/LEFT As well as remote monitoring, Synology delivers lots of security features

SPECIFICATIONS

4-core 3.35GHz AMD Ryzen V1780B processor ● 8GB DDR4 ECC RAM (max 32GB) ● 8 x LFF/SFF hot-swap SATA drive bays ● 2 x M.2 NVMe SSD slots ● 3 x gigabit Ethernet (MGMT, 2 x LAN) ● 1 x 10GBase-T ● 3 x USB-A 3.2 Gen 2 ● 2 x eSATA ● PCIe slot ● 250W internal PSU ● 343 x 243 x 166mm (WDH) ● 5yr hardware warranty

TerraMaster F8 SSD Plus

Pricey, but this innovative 8-bay all-flash NAS appliance delivers impressive 10GbE performance

SCORE ★★★★☆

PRICE Diskless, £608 exc VAT from amazon.co.uk

ABOVE The tiny F8 SSD Plus comes with eight internal M.2 NVMe slots

TerraMaster has a fine reputation for delivering ultra-compact NAS appliances and it goes one step beyond with the F8 SSD Plus. Measuring a mere 61 x 140 x 178mm (WDH), this little plastic box is the first NAS we've seen to present eight internal M.2 NVMe slots.

There's plenty of power on tap, as the appliance employs an 8-core 1.8GHz Intel Core i3 N305 mobile CPU partnered by 16GB of fast DDR5 RAM, upgradable to 32GB. The F8 SSD Plus isn't cheap, but TerraMaster also offers an F8 SSD model with a 4-core 1.7GHz Intel N95 CPU with 8GB of DDR5 memory for around £70 less.

Network performance won't be held back as the F8 SSD Plus is equipped with a 10GBase-T port. You also get three 10Gbits/sec USB 3.2 Gen 2 ports and an HDMI port for CLI output, while cooling is handled by two 5cm diameter fans in the base, which are almost silent.

Installing NVMe SSDs is simple: a thumbscrew releases the internal chassis, which slides out for easy access. You have four slots on each side and the kit includes a full set of aluminium heatsinks and pads, although we weren't impressed with the elastic bands provided to keep them in place.

TerraMaster's compatibility list offers a reasonable choice of devices from the likes of Samsung, Seagate and Western Digital, and although our Kingston Data Centre NVMe SSDs weren't listed, the appliance accepted them. Don't waste your money on costly PCIe 4 devices, though, as the N305 CPU only has PCIe 3 lanes.

Installation is deftly handled by a browser-based wizard, which downloaded and applied the latest TOS 6 operating system. Our Kingston SSDs were correctly identified and the wizard automatically created a TRAID array, which uses all available devices regardless of their size without incurring any capacity overheads.

To test performance, we hooked the appliance up over 10GbE to a Dell PowerEdge R760xs Xeon Scalable server running Windows Server 2022. Sequential NAS speeds are great, with a mapped share returning Iometer read and write rates of 9.2Gbits/sec and 8.3Gbits/sec.

Swapping to random read and write operations saw sustained read and write speeds of 9.3Gbits/sec and a noticeably lower 4.7Gbits/sec. IP SAN performance was in the same ballpark, with a 500GB iSCSI target recording sequential read and write rates of 9.2Gbits/sec and 8.4Gbits/sec, while random operations delivered 9.2Gbits/sec and 4.8Gbits/sec.

The TOS 6 web console is easy on the eye and has been redesigned with a ribbon menu across the top for quick access to the most common management functions. Apps are in abundance, with 51 now available for download from the App Center.

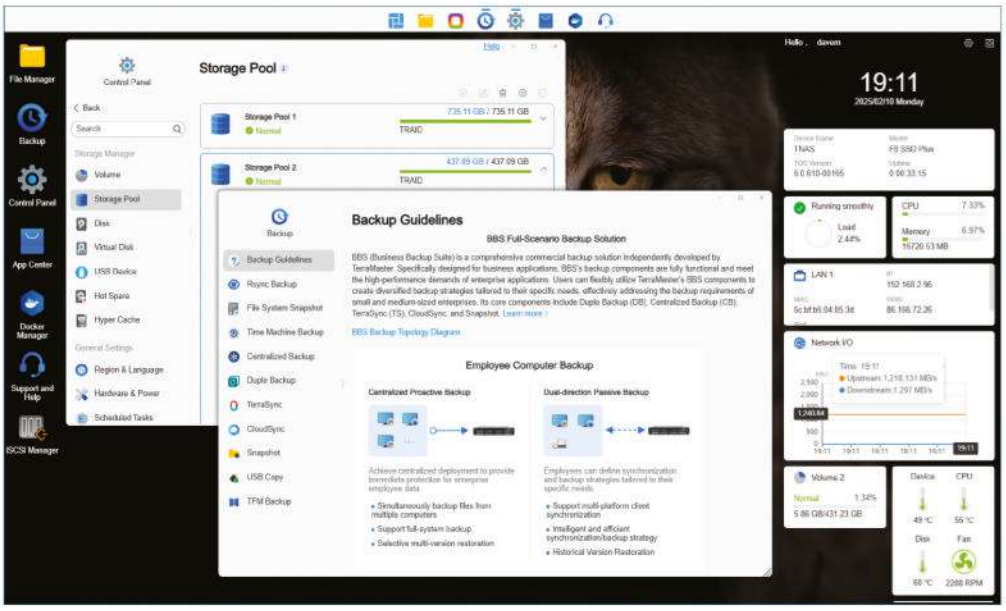
"The F8 SSD Plus is equipped with a 10GBase-T port. You also get three 10Gbits/sec USB 3.2 ports and an HDMI port for CLI output"

These include the Backup app, which provides a central location for quick access to all the suite's associated modules. Along with Rsync support, Btrfs file system, NAS share and iSCSI LUN snapshots can be run at regular intervals. TFM (TerraMaster folder mirror) handles local or remote copies of shared folders, and CloudSync supports 12 storage providers including Amazon S3, OneDrive and Dropbox.

The HyperLock-WORM feature is a valuable ransomware protection feature that allows you to assign custom retention periods to volumes during creation. The Enterprise mode allows data to be modified or deleted after the set period has expired, while the Compliance mode stops data from ever being changed.

The F8 SSD Plus is a small, quiet and powerful NAS appliance, although your initial outlay will be dwarfed by the cost of filling it with high-capacity NVMe SSDs. Even so, it's around £200 cheaper than Asustor's 6-slot FS6806X, delivers great 10GbE speeds and TerraMaster's TOS 6 offers plenty of useful apps.

BELOW FlowMon data can be fed into the WUG console while the Top 10 view shows devices that need attention



SPECIFICATIONS

1.8GHz Intel Core i3 N305 processor • 16GB DDR5 SODIMM (max 32GB) • 8 x PCIe 3 M.2 2280 NVMe SSD slots • 10GbE • USB-C 3.2 Gen 2 • 2 x USB-A 3.2 Gen 2 • HDMI 2 • 61 x 140 x 178mm (WDH) • 72W external PSU • 2yr limited warranty

Ugreen NASync DXP6800 Pro

The OS is a work in progress, but this powerful business NAS packs an impressive hardware spec for the price

SCORE ★★★★☆

PRICE Diskless, £980 exc VAT from sotel.de

The SMB NAS market is about to get a lot more interesting as Ugreen steps up for a piece of the action. Many businesses will be familiar with Ugreen's high-quality PC accessories and power chargers and it makes its play for its share of the NAS market with a family of six desktop appliances.

The attention to detail is clearly evident, as the 6-bay NASync DXP6800 Pro on review is extremely well built. What lies beneath the sleek aluminium shell is even more interesting as it offers an incredible specification for the price.

It's powered by a 10-core Intel Core i5-1235U mobile CPU and comes with 8GB of DDR5 memory, upgradable to 64GB. Port choices are remarkable: it has pairs of 10GbE multi-gigabit ports, Thunderbolt 4, USB-A 3.2 and USB-A 2, an integral SD 4 card reader and an HDMI 2 port to pipe video from the CPU's integrated Iris Xe Graphics chip.

Telescopic tool-free carriers are used in the front bays, and a spring-loaded hatch underneath provides easy access to the two memory slots and a pair of M.2 NVMe SSD slots that can be used as a storage pool or cache. Two 9cm diameter cooling fans lurk behind the rear magnetic dust cover and, during testing, we found the appliance to be whisper-quiet.

A PCIe expansion slot is also provided, but you'll need to carefully remove 11 screws to access it. The documentation shows you how, and the Broadcom dual-port 10GbE card we fitted worked fine.

For testing, we installed four 4TB WD Red Pro HDDs and loaded Ugreen's web portal to initialise the appliance. We used the UGOS Storage Manager app to create a RAID5 storage pool and added two Kingston M.2 NVMe SSDs to test caching.

When Ugreen launched the NASync family last year its UGOS software only offered 16 apps, but these have since been increased to a total of 24. They include the Virtual Machine hypervisor app, a Netdisk tool for OneDrive file syncing, an Online Document app for file-sharing and the Video Center and Music multimedia apps.

Much more capability needs to be implemented, though, as you can't encrypt storage pools, volumes or shares. Despite supporting the Btrfs file system, snapshots aren't currently available and IP SANs have yet to be implemented.

The Sync & Backup app secures local data to a remote Ugreen NAS and vice versa, and also supports Rsync servers. Load the Ugreen NAS Windows or macOS desktop app and you can create sync tasks that secure selected data to a shared folder and update it in real-time.

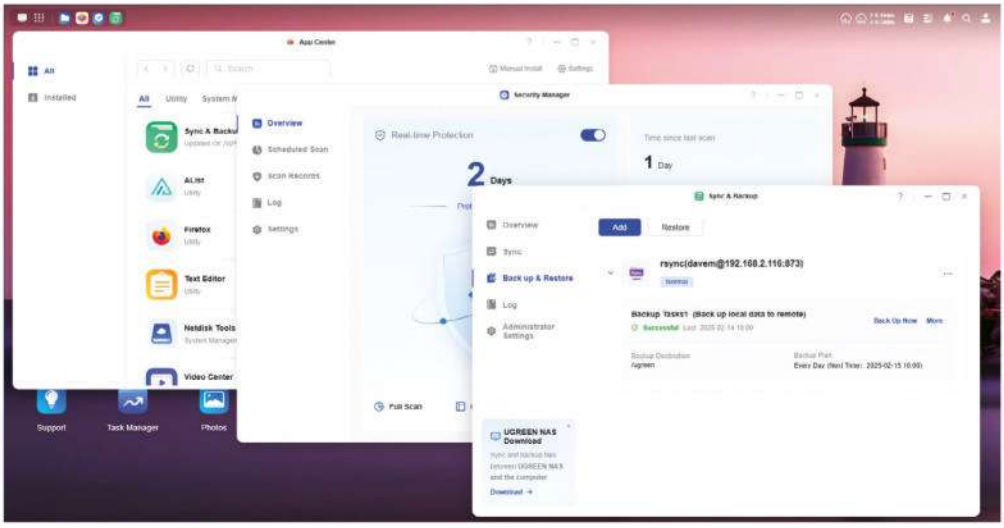
ABOVE The well-built NASync DXP6800 Pro offers an incredible spec for the price

To test performance, we plugged the NAS into our 10GbE network and mapped a share to a Dell PowerEdge R760xs Windows Server 2022 host. NAS speeds are reasonable, with Iometer reporting sequential read and write rates of 8.9Gbits/sec and 6Gbits/sec. These could have been higher but UGOS currently supports only 1,500-byte MTUs (maximum transfer units) and not Jumbo frames.

"Port choices are remarkable: it has pairs of 10GbE multi-gigabit ports, Thunderbolt 4, USB-A 3.2 and USB-A 2, an integral SD 4 card reader and an HDMI 2 port"

Real-world large file copies between the appliance and server averaged around 2.3Gbits/sec and 2.2Gbits/sec, while securing a 22.4GB folder with 10,500 small files returned 1.2Gbits/sec. An SSD cache is worth the extra spend as sequential and random writes improved by 21% and 328%, read and write rates for large file copies increased by 47% and 61%, while our backup test saw a 39% speed boost.

The NASync DXP6800 Pro, is a powerful business NAS solution although there's work to be done on the UGOS software if Ugreen intends to compete with the established names. That said, if you want a superbly built NAS with dual Thunderbolt 4 ports, the DXP6800 Pro is top value as Qnap's 6-bay TVS-h674T costs over twice as much.



BELOW The UGOS software provides a security scanner and data backup tools

SPECIFICATIONS

10-core Intel Core i5-1235U processor • 8GB DDR5 SODIMM (max 64GB) • 6 x hot-swap SATA LFF/SFF drive bays • 2 x M.2 NVMe SSD slots • 2 x 10GbE multi-gigabit ports • 2 x Thunderbolt 4 • PCIe x4 slot • 2 x USB-A 3.2 Gen 2 • 2 x USB-A 2 • HDMI 2 • SD 4 card slot • 250W internal PSU • 3yr hardware warranty

EnGenius ECW516L

Modest performance, but this Wi-Fi 7 AP offers good cloud management and plenty of features for the price

SCORE ★★★★☆

PRICE £159 exc VAT **from** solwise.co.uk

EnGenius has a fine reputation for delivering high-performing Wi-Fi 7 access points (APs), and it now turns its attention to small businesses with a family of three "Lite" models. The ECW210L and ECW212L are Wi-Fi 6 APs, while the flagship ECW516L on review brings Wi-Fi 7 into play.

With a price a shade under £160, the ECW516L offers a lot for your money. Its big BE14000 rating presents eight spatial streams: two for its 2.4GHz radio and three each for the 5GHz and 6GHz bands, with theoretical maximum speeds of 700Mbits/sec, 4,300Mbits/sec and 8,700Mbits/sec respectively.

To keep costs down EnGenius has replaced the powerful Qualcomm Networking Pro 1220 platform in its higher-end APs with a 2GHz MediaTek MT7986A A53 CPU. The ECW516L has a 2.5GbE multi-gigabit port which only requires an 802.3at PoE+ power source.

As with all ECW models the ECW510L must be cloud-managed, and EnGenius has introduced a new low-cost Cloud Lite service offering a reduced feature set. The Lite APs include a basic plan, which is similar to the standard ECW version but doesn't support the Hotspot 2.0, Radius security and dynamic VLAN services. You can upgrade to a Lite Professional plan which ups log storage from one to 30 days and adds features such as device configuration backups and real-time views of connected clients.

It only took a minute to add the ECW516L to our cloud account, using the Cloud To-Go iOS app to scan the QR code on its base. A soon as it had been added to our organisation, it took all our predefined wireless settings and started broadcasting them.

The cloud portal presents a non-customisable dashboard with plenty of information on managed switches, APs and wireless clients, with graphs below for wireless throughput plus the top APs, clients and SSIDs. Enable the application control service on your SSIDs and the dashboard adds another table below showing the top ten apps and their bandwidth usage.

It supports up to eight SSIDs per site. For each one, you can choose the active radios, enable L2 isolation, band steering and fast roaming, and apply download and upload rate limits for the entire SSID or per client. Sensibly, EnGenius won't permit open, unsecured SSIDs to be created and you can choose from OWE (opportunistic wireless encryption) to present safe open public networks or the appropriate WPA version.

With the ECW516L connected to the lab's Zyxel XS1930-12HP 10GbE PoE++ switch, we ran performance tests using a Lenovo Windows 11 24H2 desktop client equipped with a TP-Link Archer TBE550E Wi-Fi 7 PCIe adapter. Starting with Microsoft's NTttcp utility, we recorded raw upstream and downstream speeds between the desktop and a Windows server on our 10GbE LAN of 235MB/sec and 202MB/sec.

Real-world file copies between the client and server returned average close-range speeds of 191MB/sec, dropping to 179MB/sec with the AP moved ten metres away and into an adjoining room. Performance isn't particularly exciting but is in the same range as other budget-priced Wi-Fi 7 APs we've tested.

ABOVE **The ECW516L is an affordable choice for SMEs looking to upgrade to Wi-Fi 7**

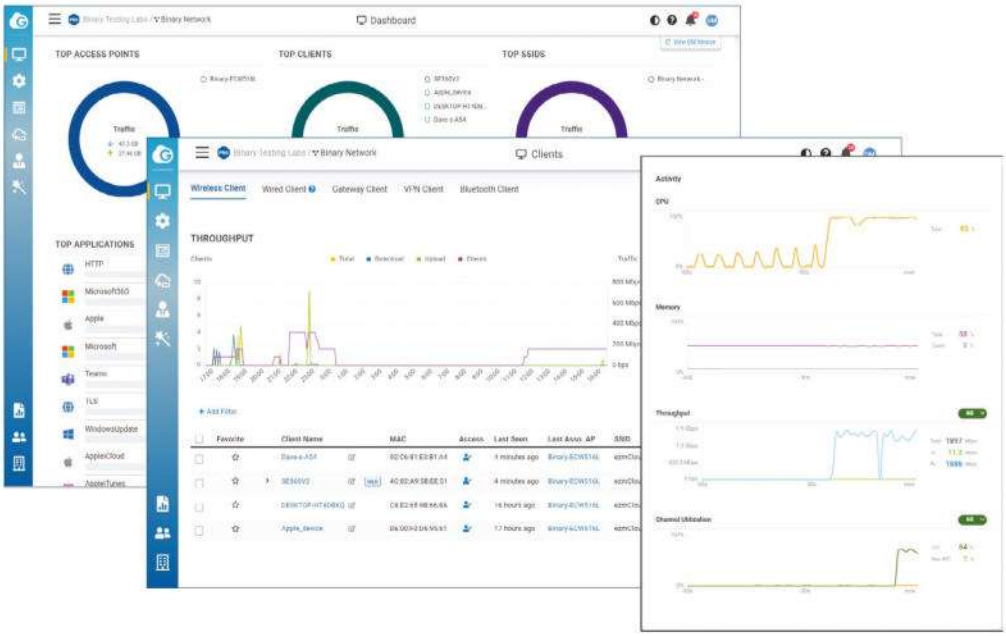
"Its big BE14000 rating presents eight spatial streams: two for its 2.4GHz radio and three each for the 5GHz and 6GHz bands"

We did notice the MediaTek CPU wilting during our NTttcp stress tests as the cloud portal's AP diagnostics graph showed utilisation ramping up to nearly 100%. Use the application analysis service with caution, too, as we found its overheads can drop wireless performance by up to 10%.

Our TP-Link Wi-Fi 7 adapter supports MLO using MLMR (multi-link multi-radio) and, after enabling it on the ECW516L, we could see that it had created a link across the 6GHz and 2.4GHz radios. Windows showed the aggregated link speed as 6,453Mbits/sec, but further runs of NTttcp didn't see any appreciable performance improvements.

The ECW516L compares well on price with the competition making it an affordable choice for small businesses seeking a Wi-Fi 7 upgrade. It's easy to deploy, and the EnGenius Lite cloud portal offers a fine range of wireless network management features. **DAVE MITCHELL**

BELOW **The EnGenius cloud portal offers excellent remote management features**



SPECIFICATIONS

Tri-band 2.4GHz/5GHz/6GHz 802.11be Wi-Fi 7 router • quad-core 2GHz MediaTek MT7986A A53 SoC • 2.5GbE multi-gigabit LAN/802.3at PoE+ • wall/ceiling mount kit • 12V DC input (adapter not included) • 205 x 33 x 205mm (WDH) • 616g • 1yr hardware warranty

TP-Link DR3650v

A well-priced, all-in-one communications, security and networking solution that's packed with features

PC PRO RECOMMENDED

SCORE ★★★★★

PRICE £208 exc VAT
from broadbandbuyer.com

ABOVE The DR3650v is TP-Link's first DSL gateway appliance, and it's a winner

TP-Link has consistently offered an impressive range of business networking products, so it comes as some surprise that the DR3650v is its first DSL gateway appliance. It makes a grand entrance, though, as along with multi-WAN backup and load-balancing services, it's designed to provide SMBs with an affordable all-in-one communications solution.

Along with five gigabit ports, you get a dual-band AX3000 Wi-Fi 6 access point, with the USB-A port supporting 4G dongles for further WAN backup. Security comes via an SPI firewall with deep packet inspection (DPI) and web content filtering, it supports IPsec and SSL VPNs and has a built-in VoIP IP PBX.

The appliance's RJ11 WAN port supports VDSL2/VDSL2 35b and ADSL2+ services and the two RJ11 FXS ports are for connecting legacy phones and fax machines. The first gigabit port can function in LAN or WAN mode; where you have multiple WAN connections, you can enable load balancing or use them in failover mode as primary and backup links.

This all seems quite remarkable when you consider the appliance only costs £208, but there's more. It also offers you the choice of standalone or cloud management, with Broadbandbuyer even including a three-year Omada hosted cloud controller subscription in the price.

Standalone deployment is swift. A wizard guides you through creating a new admin account, configuring your WAN ports and adding SSIDs for both radios. For VDSL/ADSL providers, TP-Link seems to have every possibility covered, with 33 available in the dropdown list for the UK.

The web console provides easy access to all features, which is just as well as there are a lot to play with. Wireless services include L2 isolation for guests with the 5GHz radio supporting the 160MHz channel, and if you use cloud management, you can wirelessly mesh the appliance with other compliant TP-Link APs.

Wireless performance on the 5GHz 160MHz channel is fine. Microsoft's NTttcp utility recorded upstream and downstream speeds of 113MB/sec between a Wi-Fi 7-equipped Windows 11 desktop and a server on the appliance's gigabit LAN.

VoIP features are basic. To use the IP PBX, you create provider profiles and assign phone numbers to registered telephony devices. You can create a phone book for saving contact details, view a call log, use DND to block incoming calls and save voicemails to a USB storage device.

The firewall offers options to enable DPI, customise it with filter rules and enforce application controls using a built-in list of over 2,800 popular apps. Web access controls are limited as TP-Link doesn't offer category-based filtering services and only allows you to apply manually created URL and keyword lists to block access and stop specified file types from being downloaded.

"TP-Link's first DSL gateway sets a high standard as it combines WAN redundancy and failover services with a treasure trove of features"

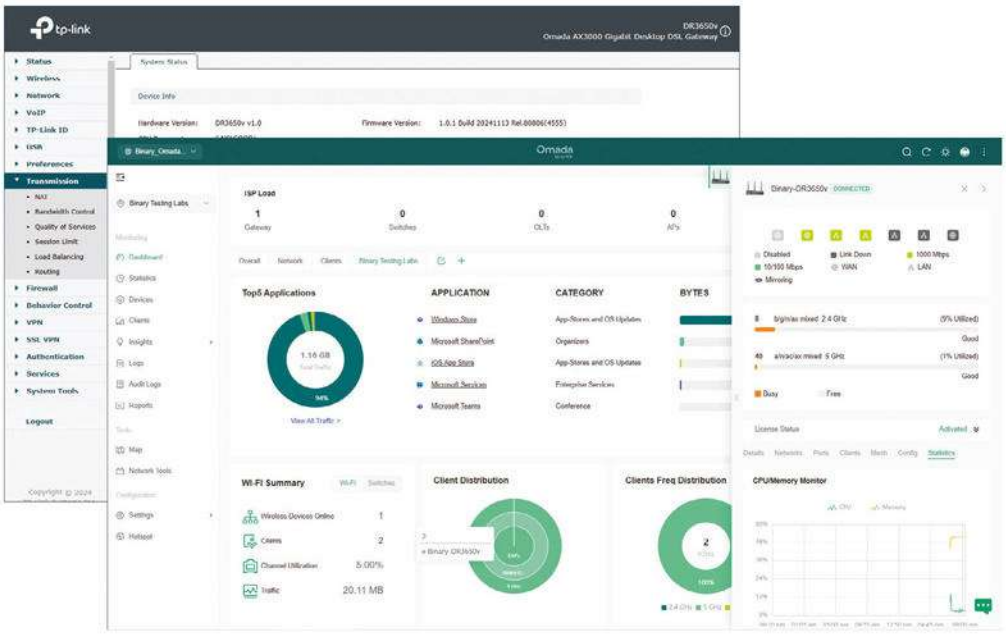
To add the DR3650v to our Omada cloud controller account we entered its serial number and, after it had been adopted, we assigned a cloud licence to activate it. It then appeared as a new gateway in the portal dashboard and started broadcasting our predefined wireless SSIDs.

Everything you can do in standalone mode is available in the cloud portal settings page. A nice touch is that the main settings menu is neatly organised into the same categories as standalone mode, so it won't take long to find a feature you want to configure.

We prefer cloud management, as the portal provides a lot more information than the local interface. A ribbon across the top shows internet capacity, gateway usage, switches, APs, clients and wireless guests, and below this you can create multiple dashboards and populate each one with a wide range of widgets including charts of the top applications and their traffic.

TP-Link's first DSL gateway sets a high standard as it combines WAN redundancy and failover services with a treasure trove of features. Web-filtering and VoIP services are basic, but the incredibly low price will appeal to small offices or businesses that want an all-in-one networking hub. **DAVE MITCHELL**

BELOW The appliance can be deployed in standalone mode or cloud-managed



SPECIFICATIONS

Desktop chassis ● RJ-11 VDSL2/ADSL2+ port, 2 x RJ-11 FXS ports, 5 x gigabit ports (LAN/WAN, 4 x LAN) ● 2.4/5GHz 11ax Wi-Fi 6 ● 3 x external aerials ● 2 x USB-A 3.2 Gen 1 ● external PSU ● 226 x 131 x 35mm (WDH) ● 1.1kg ● web browser or Omada cloud management ● limited lifetime warranty

What to do when your critical app goes offline

Businesses are increasingly reliant on mobile apps and remote services; Steve Cassidy asks what you can do when something goes wrong

Apps are everywhere. Many businesses, especially smaller ones, are taking advantage of convenient, turnkey mobile apps to run their day-to-day operations – but they're risking potential disaster if one day a critical app stops working. It's vital to think ahead, consider how to prepare for the eventuality, and know what to do if it comes to pass.

First, some definitions. The word "app" has come to mean any executable program, but I'm talking here specifically about mobile apps designed for a phone or tablet, which typically serve as your front end to a hosted service and are downloaded from a third-party app store, rather than directly from the publisher.

That last part may provide a certain sense of security. When you know some huge intermediary like Apple or Google is actively vetting these apps, you can feel confident about things such as app quality, data security and continuity of service. Unfortunately, that feeling is entirely unsupported by the facts. As long as the app isn't actively malicious and runs on the latest version of the hardware and OS, the app platform provides no real assurances.

Indeed, it acts as a barrier between you and the developer. If you need help or want to make a complaint about an app you've got from the store, your options for reaching the publisher may be limited. Relevant information such as the address and contact details of the development team, and their lawyers and accountants, are rarely easy to track down.

Of course, there's nothing new about not knowing who's ultimately responsible for the tools you rely on. In my early programming efforts I never knew a single one of the men behind the tools and compilers I relied on. But as app-based computing has grown, the whole idea of central IT has declined, in favour of the outsourced, self-service computing model. Without in-house developers and support staff to turn to, users are left, quite literally, to their own devices, reliant on absent, unreachable app publishers.

The stage is thus set for all sorts of issues when something goes wrong, or when an update raises concerns that no-one is around to answer. This isn't to say that app publishers won't offer decent technical and user support, but verifying the scope of it for yourself should be one of the first considerations when you're considering whether to adopt an app-based service.

ABOVE Many SMEs now rely on apps for their business

"If an app stores all your figures and records in its own protected environment, it's not fit for purpose"

Preventative measures

They say, in rather old-fashioned terms, that an ounce of prevention is better than a pound of cure. This is certainly true in the field of apps. A remote outage or an internal accident could leave you with no means of recovery; your best hope for surviving the situation is doing your homework and planning ahead for such scenarios.

The first thing to ask is, does the app represent the only means of access to your data? I shouldn't need to expand on this: if an app stores all your figures and records in its own protected environment, with no way for you to get at them except via the goodwill and competence of the operator, it's not fit for purpose.

This is a bigger issue than it ought to be, because while developers might not intend to hoard your data, there's a good chance they've built their app on a multi-tenanted hosting service, where your data mingles with everyone else's as a big pool of relational data. It's simply not technically feasible to allow individual customers to make their own local copies of the back-end database image.

Your best bet, therefore, is to look for a service that offers an alternative means of access outside of the app, such as a web portal. This isn't an unreasonable ask: the developers themselves will probably already have something like this for their own management purposes. So if you can get hold of the developer, it's well worth asking about emergency access before you invest: don't leave the question until things go pear-shaped, because once the app goes down the company providing it will probably be focusing more on fixing that than setting up logins and remote access for you.

Indeed, I would in general strongly recommend cultivating a relationship with the developer at the earliest opportunity. If an app is going to be a material part of your business workflow, you really want to be as involved as possible in its ongoing development, and the broader situation of the business that provides it. I had one client who kept an IRC chat window open at all times to their software provider, just typing in support requests and leaving the far-end participant to respond when they were ready. This approach, more or less the exact opposite of the arm's-length app-store model, worked brilliantly for both parties.

As well as talking to the people that make the app, listen to the people that use it. App stores hate to send you away empty-handed, so if you search for something with no good matches, they'll just show you bad matches instead. Reading the reviews can help steer you away from the real rubbish, but ideally it's worth seeking out a business that's in a similar position to you – not one that's directly competing with you, obviously – and sounding them out regarding their own experiences and concerns. Take them out to lunch and just see what they have to say, while filtering out anything that sounds like social media hysteria or personal sour grapes.

"I would in general strongly recommend cultivating a relationship with the developer at the earliest opportunity"

Don't keep your findings to yourself, either. If you hear anything that raises concerns or questions, take them back to the publisher. It may be that they've already addressed this or that issue; that shows a positive, responsive attitude that bodes well for the future. If they don't have sensible commercial responses, or don't respond at all, then that's your cue to look elsewhere.

Who's to blame when things go wrong?

Apps are designed to keep things as clean and simple as possible for the user, which usually means they offer no features for troubleshooting or technical diagnostics. If something goes wrong, it may not even be obvious whether the problem is with the service or your own infrastructure. One past client of mine was very proud of their leading-edge 10-megabit internet pipeline, without realising that it was delivered in the form of ten one-megabit pipes stitched together by expensive routers. The setup operated faultlessly for about a year, before it started exhibiting the most perplexing intermittent, inconsistent errors. Cue much yelling down the phone at the wrong people – until it was discovered that the real cause was one of the bundled lines going bad.

That might be an unusual case, but there are any number of scenarios where an apparent issue with the app might have nothing to do with the operator. So once you've invested in that relationship, don't go blundering in pointing fingers and playing the victim. If it turns out that they've genuinely screwed you over, it's always open to you to pursue legal action, but I'd be cautious about rushing to that option. Not least because you're unlikely to recoup much from the developer.

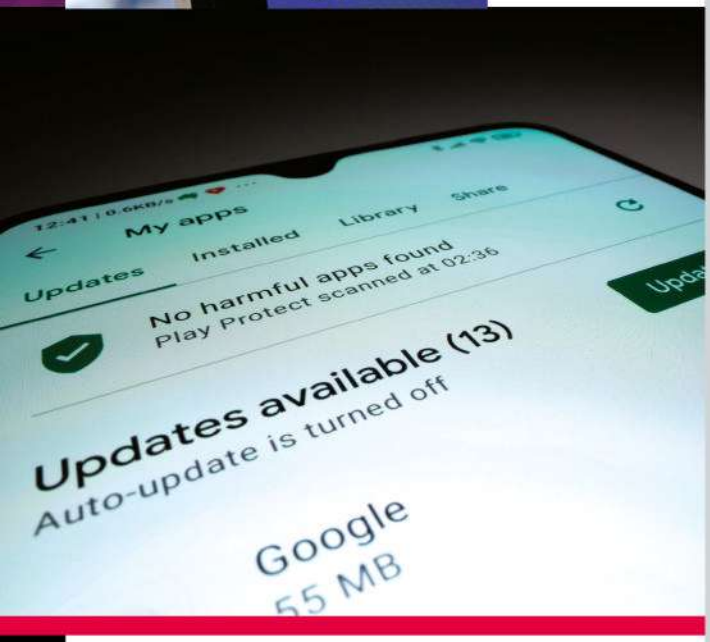
If the issue really does stem from a developer-side disaster – say, their hosting provider has been shut down, or a tornado has taken the roof off the data centre – the best thing you can do is usually leave them alone. They know you've been affected, and the less you overburden them, the sooner they're likely to deliver a workaround. After all, their business is on the line, too.

If you think the developer is persistently not doing things right then of course you can consider leaving – but, with a bit of *Dragon's Den* thinking, could you alternatively take on an interest in the business? A share swap or IPO process could be much cheaper and more effective than a lawsuit, if they have enough market share and a reasonably loyal user base.

Trusting the provider's cloud host

Naturally, your business will have all sorts of provisions and plans in place for what to do if your cloud host lets you down, but you have no visibility

ABOVE Google and Apple may vet apps, but it's hard to take up any issues with the publisher itself



LEFT App stores can offer no guarantees when it comes to problems with apps

into whether your app provider has done the same thing. A fledgling venture may be cutting costs wherever possible, and running its service on hope, a single server, some baling wire and gaffer tape.

As well as checking out how you can access your data in the event of an app outage, therefore, you should investigate how the app itself will cope with a data centre outage. Aside from the reassurance that some sort of plan is in place, it's well worth understanding how their plan B might affect your operations: for example, if it means access times could temporarily slow to a crawl, you can plan your processes around that. Think too about problems that might arise at your end: if your creaky old DNS server caches the main host address, will you hit problems when the app's failover system expects it to be pointing elsewhere in the cloud?

While the rise of app-based services demands new thinking on procurement, deployment and support, the underlying principles of managing your exposure are the same. Set your limits of commitment very carefully when it comes to business-critical services – as always, these require an involved and mutually beneficial relationship, which the standard app store model certainly doesn't guarantee.

ABOVE The rise of app-based services demands new thinking on support

How bad can it get?

The troubles of dealing with a remote app developer remind me of a situation I was involved in a few years ago. This one didn't involve an actual app, but it otherwise touched on the same principles and issues.

It all began when the time came for one of my clients to undertake their regular annual code maintenance session. This was carried out by a third-party IT services provider, which was supposed to close the accounts for that year, work through a sizeable patching and updating process on the code, and finish with a general tidying up of the weighty SQL database that underpinned the various client access modes – some classic executable, some apps, some web page presentations, all accessing the same underlying data.

Precisely what actually happened will forever be shrouded in mystery, but we can be reasonably sure that the service provider somehow managed to break the live SQL database; we know this because they then spent days, weeks even, promising a fix that never quite materialised. To be fair, they certainly seemed to be trying, via endless remote-access diagnostic sessions. But they also seemed not to know how to proceed, and to be looking for another direction in which to divert the blame, sending quite a lot of accusatory emails claiming that the infrastructure-grade server they'd been praising for the past 11 years had suddenly become unreliable and slow (it hadn't).

The next I heard of this poor client, he was drafting a letter explaining in profuse and humiliating detail why this data disaster meant he was unable to present his annual tax return by the deadline date. Among other things, the letter was intended to explain to the authorities exactly who was responsible for the situation, and for presenting a solution.

Except that, even in such a heavyweight communication, the client was unable to name names. The service provider would reveal no details of its resourcing model, for reasons that would eventually become apparent: taking advantage of the anonymity of their remote-access service, they had handed the annual update process to a lone, unverified, outsourced database person.

Perhaps tellingly, when I volunteered to drop by their office and have a chat about how to avoid such eventualities in the future, the response was one of great reluctance. This, I am sure, is because the operator didn't wish to reveal the true scale of their operation. In my time I've visited companies with some very respectable resource pools for dealing with urgent issues, including Facebook (300) and Unilad (200), at a time when both were growing fast. In the case of this supplier, I strongly suspect the only actual occupant of the office was the boss.

As I say, this story doesn't involve a downloadable app, but it's about a service provided in a similar way – and the way this company handled the cock-up is reflective of what you can expect from some app providers. While there's nothing new about small, scrappy companies trying to dress themselves up as something bigger and more trustworthy, the advancement of technology has made it easier for them to punch far above their weight – as long as things are going well. When a problem emerges, all they can do is hide, obfuscate and pray their outsourced resources can fix the issue sooner rather than later. Even if they genuinely care about the workflow and financial security of their customers, they're simply not in a position to safeguard them.

You won't be shocked to learn that the client decided to make a break with this particular supplier. The database remains unrepaired even to this day, but thankfully the data loss turned out to be limited to a small range. We discovered this when, as part of the goodbye agreement, the software provider handed over a perpetual licence, allowing my client to log back in to the old software configuration and explore what remained of the database.

For this purpose we kept a couple of PCs and a SQL Server machine frozen in the configuration that best supported the old software, while moving other applications away; the tax men were kept apprised and accepted the efforts being made to get some usable figures. And the even better news is that half a dozen other similarly affected companies who had been using the software have now formed the core of a potential user pressure group, because ultimately the only thing that's really going to get providers of remote apps and services to up their game is commercial pressure.

What is ITaaS?

Do you need your own IT department? Steve Cassidy looks at an ambitious outsourcing model – and asks who it's right for

Surely all "as a service" offerings are IT, in one form or another?
They are – but most of them focus on one specific aspect of the IT workload. "IT as a service" takes in the broader management and support of the computing estate. That includes things such as making sure the right servers are available and accessible, along with internal services such as desktop support and mobile-device management.

So we're talking about a flexible, outsourced IT department?
We are, and that's a tempting idea for would-be entrepreneurs hoping to start the next megacorporation in their back bedroom, or under the eaves of a WeWork. As with all "as a service" offerings, there's no upfront expenditure required, and once you're running you need pay only for the resources and services you use.

However, ITaaS isn't just another hosted product: it enmeshes more closely with more parts of the business than your typical hosted service. Among other things, this means you can't switch providers or service levels as quickly and easily as you can with regular cloud-based services.

Is that a big problem?
It depends. For an established firm with its own website and customer app, a bespoke ERP database and so forth, you're investing a lot of reliance in a third-party provider. In a scenario like this, keeping your IT resources in house can give you a closer, more reliable connection between the business, the systems it relies on and the people who manage them.

At the same time, company bosses are always interested in cutting fixed costs, such as staffing overheads. And another benefit of ITaaS is that it does allow you to rapidly scale up the urgency and computing resources when needed.

So it's about emergencies, rather than everyday operations?
Regardless of how your business is structured, it's always the emergencies that place the highest demands on your IT team. ITaaS gives you options to quickly draft in extra help when disaster strikes.

It's not a magic wand, though. Sudden, unplanned increases in demand can be costly – and while the provider can draft in additional bodies, these will usually be agents who aren't au fait with the quirks of your particular systems.

In other words, ITaaS doesn't scale like other hosted services?
In some areas it can. If your servers are getting bogged down, your ITaaS team can put more cloud VMs online and get the job done faster. And while it's true that there's no infinite army of IT experts to draw on, that may be a less pressing problem than it seems. Do you need massive scalability in applying updates to your accounts department's web browsers to stay in sync with your bank's security requirements? Probably not.

So is ITaaS the future?
ITaaS absolutely has a place. It's an ideal model for hosting centres and server farms, which can be easily managed with standardised hardware, lots of scripting and a relatively small group of techies.

Most businesses, however, are messier than this. Perhaps one day the typical commercial operation will be boiled down to a set of standardised workflows and contractual relationships – but for now many of us still find value in an organic, assimilated IT function that understands the nuances of what your business does and how it works. If that's you, look closely at what ITaaS can do for you, and what it can't.

Security and backups

If you're on the fence about ITaaS, one consideration that might swing your decision is security. Staying on top of the latest threats and updates can be an overwhelming responsibility – especially if you're running your offices on a hodge-podge of IT systems, accumulated as needed over the years. Handing that role over to a managed service provider takes a load off your mind, and may also make it easier to migrate to more stable and manageable platforms.

This is a key benefit that individual cloud services can't offer. For example, when you lease hosted VMs or database instances, all you get is the platform; the provider might take responsibility for keeping the underlying codebase patched and isolated, but it can't do anything about any downstream vulnerabilities in your own software or workflows.

Similarly, ITaaS can include backup services that go well beyond this or that cloud platform. User devices, shared folders, local servers and more can all be protected under one contract.

If you're planning to outsource these vital functions, however, it's crucial to do your research and pick a provider with an impeccable track record. If your ITaaS partner fails to protect your data from a security breach or a server crash, it's your business that will have to deal with the fallout.

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Real world computing

Expert advice from our panel of professionals

JON HONEYBALL

"I'm tired of dumb items. It really is time that robotics and human-machine interactivity was lifted to a new level"

Remember Microsoft's Barney? Well, Apple's research team is upping the game almost three decades later with expressive robots that interact with you, and it might just be amazing

I have a few things on my mind this month. Let's start with something that happened back in January when I was at CES in Las Vegas, along with Tim and Barry of this parish. I usually buy an eSIM for trips to the States from one of the online vendors. This not only provides a second number – always useful – but means I don't get into any arguments over what is "acceptable use" on my "unlimited data" SIMs from UK providers.

This time, I decided I wanted to have a USA phone number, just in case I needed to get in contact with colleagues. My usual go-to provider, Holafly, wouldn't be appropriate because its eSIM offerings are purely data. With hindsight, I should have remembered that the lab phone system runs on 3CX, and that I have the 3CX client on my phone. So my phone is just an extension number at the lab back in the UK, and this connects over data.

Anyway, I decided to give T-Mobile another go. I tried it a few years back and found it annoyingly clunky when setting up the eSIM. There is an app where you register, choose your plan and pay; the app then installs everything and sets it up appropriately. Back then, it wasn't particularly seamless, but this time around it just worked. When I landed in Los Angeles, I enabled the eSIM.

Everything worked fine except for one wrinkle. I received an SMS message saying, "Teneya, are you still interested in dental implants? – Hillcrest Dental". Obviously, I'm not Teneya, and I don't want dental implants. A quick Google showed that there is indeed a Hillcrest Dental in Las Vegas, should you need some implants in a hurry.

So what had happened here? The message was an SMS so the number that had been assigned to me had been used before by Teneya. When I checked on the T-Mobile website (**tinyurl.com/368tmobile**) it clearly says: "Number Reuse: T-Mobile holds all numbers for a minimum of 45 days to a maximum of 90 days before making them available for reuse."

Clearly, at some point, Teneya had a T-Mobile contract. For whatever reason, she'd cancelled her contract, and T-Mobile had thrown the number back into the pot and assigned it to my month-long eSIM purchase.

All of this is quite straightforward and not particularly surprising. But it did make me think about the validity of mobile phone numbers for the purpose of contacting someone in 2025. Some companies use SMS for 2FA. It wouldn't have been particularly helpful if Teneya had needed to reset a password, and the 2FA had been sent to this number, because I would have received it. Or someone else, now it has doubtless been churned once more.

Jon is the MD of an IT consultancy that specialises in testing and deploying kit
@jonhoneyball

"In the past, we put a lot of trust into phone numbers. Today, that trust is misplaced"

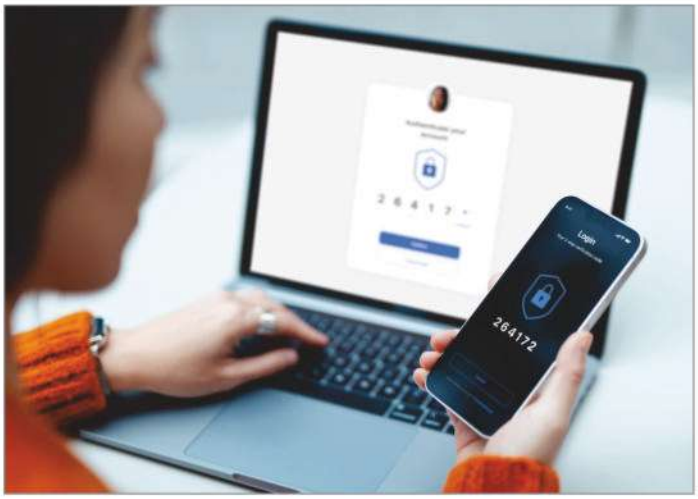
I wouldn't have had this problem, small and insignificant as this was, if I had used Holafly, because its eSIM is data only with no phone services. And its numbers are issued out of Austria on the +43 country code.

In the past, we put a lot of trust into phone numbers. Today, that trust is misplaced, whether it's because of SIM-swapping cyberattacks being used to hijack a number or, as happened here, the simple re-use of a phone number by a telco when a contract or prepay service has timed out.

Whatever happened to Barney?

Do you remember Microsoft Barney? No, he wasn't a relative of Clippy but part of Microsoft's ActiMates interactive toys launched back in 1997. Ostensibly aimed at children, they instead gathered quite a following from tech nerds like me. I only ever saw the Barney version, modelled on some psycho purple children's TV presenter, but apparently there were more in the range. These were quite clever devices, but after the initial surge of sales died out the products were discontinued in 2000.

You could operate your chosen ActiMate standalone or via a dongle plugged into a computer or TV. Barney could talk, listen and respond; I'm pretty sure he could move himself around, too. He even featured interesting tech such as cameras and switches in his paws.



BELOW Are mobile numbers secure enough for 2FA?

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The wider vision on cloud and infrastructure – p120

Used in standalone mode, Barney's vocabulary stretched to some 2,000 words, which was pretty impressive at the time. If you used the PC interface puck and software running on your PC, his vocabulary jumped to 14,000 words, which isn't too far off the typical 20,000 to 35,000 of an English speaker. Perhaps the gap is because Microsoft went to great lengths to ensure you couldn't get Barney to say anything rude.

Ultimately, Barney's usefulness was limited because ActiMates never really got integrated at an OS level. Having such integrations at an app level is almost always guaranteed to ensure an early death. So it was with our purple friend.

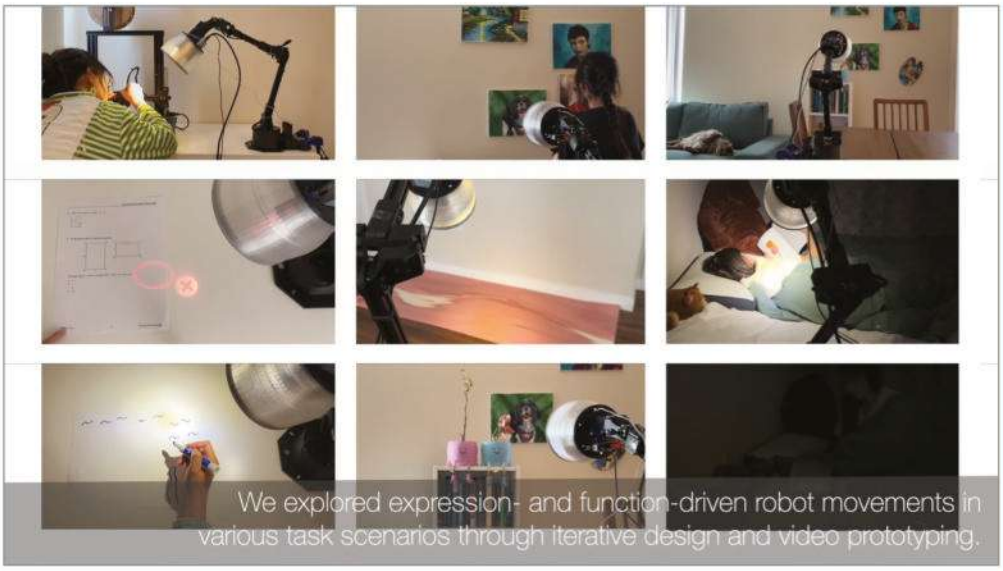
If you would like to nerd out on some of the tech, here is the patent documentation on how the control signal was encoded into the overscan space on a TV signal: **tinyurl.com/368barney**. And this paper is interesting because it was by MIT and Xerox PARC: **tinyurl.com/368paper**. For a somewhat lighter read, I recommend Barney's history page at **tinyurl.com/368actimates**.

I haven't put fresh batteries into Barney in a decade or more, but now I feel guilty. He deserves to speak in his awful jingo sing-song voice and to be annoying at a level rarely reached by normal technology.

So why was I reminded of Barney? Well, he's never really left me. We still use the Barney I bought all those years ago, for camera testing on mobile devices. He sits on top of a shop display turntable, along with a pile of other items, and the turntable rotates. This is lit by controlled studio lighting, and it makes an excellent tool for colour accuracy, resolution evaluation and determining if there are dropped frames or other jerkiness.

I write about him this month after I read a paper from Apple's Machine Learning group, in particular the Human-Computer Interaction team (**tinyurl.com/368ELEGNT**). Its title is "ELEGNT: Expressive and Functional Movement Design for Non-Anthropomorphic Robot".

In essence, it tries to make devices work in a more natural and expressive way. If you watch the video, also on the page above, it's utterly charming. It starts with a Pixar-like lamp, but brings the idea to life by showing someone interact with it – you can tell it to come closer while reading a book by using gestures, for instance. Now of course, these are demo videos, which will always show the best. But clearly Apple has got some of this technology working in a useful fashion. If you want to go further into this research, it has published a paper at **tinyurl.com/368arxiv**.


We explored expression- and function-driven robot movements in various task scenarios through iterative design and video prototyping.

Why do I think this is important? Well for too long, computing devices have been static items. Attempts such as Barney, and Sony's Aibo robotic dog of the same era, never had the capabilities to move their usefulness to the mainstream.

And to be honest, I'm now tired of dumb items in my household space. I don't mind a smart speaker in the kitchen, because it sits there playing music and taking voice controls. But an interactive item that actually provided real feedback could be at a whole different level, especially if it had display functionality, too. I know I would use speech control, especially in an AI fashion, a lot more if there was more interactive feedback than just a stark "Okay" spoken to me.

Bringing such a challenging concept to market will take a lot of bravery, but it really is time that robotics and human-machine interactivity was lifted to an entirely new level.

ABOVE **Apple's Pixar-like lamp can interact with users in a potentially useful way**

"Why was I reminded of Barney? Well, he's never really left me"

BELOW **Barney: he was the future once, you know**

Gigaclear reliability

At home, I have a gigabit fibre connection provided by Gigaclear. It replaced a site-to-site private fibre line from Openreach, which connected the house to the lab, around ten miles away. Switching to Gigaclear saves me a lot of money each month, and thanks to Ubiquiti hardware back in the lab I can use the site-to-site VPN tunnelling that makes everything so easy to join up.

I also installed Starlink because I wanted to see what Space Karen's direct-to-satellite system was like. I set it up in a failover configuration, so that the traffic goes via Gigaclear fibre unless there is a problem, and it then immediately switches over to the Starlink satellite connection. When the Gigaclear line is restored, it automatically switches back. I could load-balance between the two lines, but frankly gigabit fibre is more than fast enough.

When it works. Over the past few months, we've suffered a number of outages on the Gigaclear line, many of which were unplanned and covered a significant part of Cambridgeshire. But it's also had quite a number of planned overnight outages, too.

Now, while I fully accept that system faults are unpredictable, planned outages are necessary to keep everything going. Doing them at night is better than during the

daytime, but I can sometimes work odd hours, which is one of the perils of having clients around the world. And the UniFi app on my phone cheerfully goes "ping" when the primary line goes down and it switches to Starlink. So I notice these things, even if many or even most users would never have spotted it, because they were rightfully tucked up in bed.

Gigaclear has a status page at **gigaclear.com/network-status**, but this only appears to list unexpected outages rather than planned downtime. I'm building up a log of this myself, if only because I can.

A good alternative to Starlink would be to use a 5G connection as backup, but this is only viable if you have a strong signal. Which is notably missing from my village, so I will stay with Starlink for the moment. In fact, I expected Starlink to be a temporary experiment, but it's being called into use too often for me to feel comfortable shutting it down.

There's another perk, too: having a Starlink account means I could buy the small, battery-powered Mini unit. At £399, it's a little pricy for a weekend toy for me, but it would be invaluable next time I decide to climb a mountain range and decided I need to do a Teams meeting from my tent. Which is likely to be never.

However, I see from Starlink's website that it works at speeds up to 100mph. It would be a laugh to mount it on a top box on one of my motorbikes, and then enjoy streaming as I ride into London down the A1. It's quite possible that it would be more reliable than existing 4G/5G services, which would be a condemnation of the terrestrial suppliers.

ABOVE **The Starlink Mini will be invaluable if I need to do a Teams meeting on a mountain**

LEFT **Starlink has kept me going when my Gigaclear connection has dropped**

Keeping track of Wi-Fi

Being a test lab, we have to keep on top of Wi-Fi test standards. The problem with Wi-Fi is that you can't see it, smell it or touch it, unless your router has just caught fire.

Benchmarking a Wi-Fi system on an RF open field test site, or in an RF test chamber, is absolutely the right thing to do for specific R&D purposes. And for ensuring compliance with the various international standards. But it's a pretty lousy way to evaluate a product in its real-world use, unless you happen to live your life inside RF test chambers or habitually sit on a wooden chair in a field.

"The problem with Wi-Fi is that you can't see it, smell it or touch it, unless your router has caught fire"

This is why we test Wi-Fi systems at my house. I'm talking about Wi-Fi units themselves, of course, but also the Wi-Fi capabilities of client devices such as phones, laptops and tablets. Before anyone starts raising their eyebrows in critical fashion, I can control the Wi-Fi that is local within the house by the simple means of turning it off. Equally important, I know any nearby Wi-Fi base stations in neighbouring properties is well below 80dBm level, and hence of no significance.

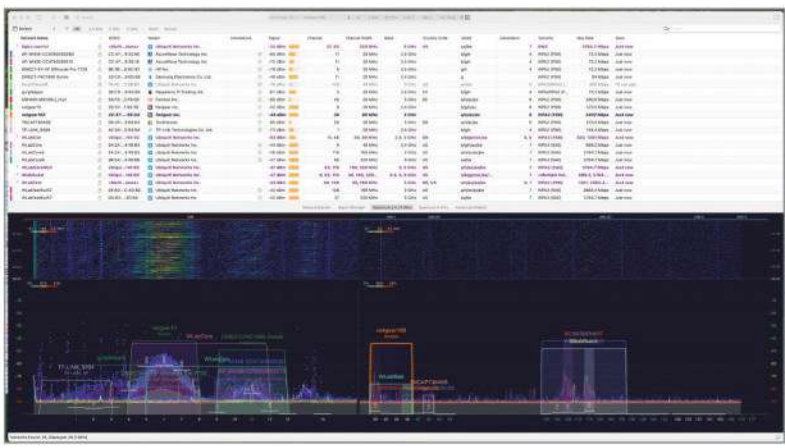
But it's not enough to convince yourself of this: it's necessary to measure it, and to do so before and during each test session. I've forgotten to turn off one Wi-Fi access point before now, for example. So you really need to look, and that requires specialist software and a proper RF spectrum analyser.

For years, my chosen tool was Chanalyzer from MetaGeek, which I used with its Wi-Spy DBx hardware. This has provided sterling service over 2.4GHz and 5GHz bands, for which I thank it. But the DBx is now end of life, and was showing its age by not supporting the 6GHz band.

MetaGeek launched Chanalyzer 6, a new software platform that tried to bring together some of the other tools under one umbrella. At release it didn't support the 6GHz band, an omission solved when Oscium released its WiPry Clarity hardware. It's expensive at nearly a grand, but I was confident it would be worth it. I then tried the new Chanalyzer 6 and, to be frank, found it didn't meet my needs at all. It wasn't a better version of the classic Chanalyzer, instead trying to be different. Like a new Coca-Cola recipe, I just didn't gel with it at all. Although the WiPry Clarity remains a useful piece of kit, the lack of proper software support for my needs was a disappointment.

Recently, Oscium released the updated Wi-Spy Lucid hardware, which is also tri-band, but scans much quicker than the Clarity predecessor. Yes, it was another grand, but worth it if you need to have the best tools. I heard, via Twitter, that MetaGeek, having merged with Oscium, would now offer an updated classic Chanalyzer version with 6GHz support. It seems to be the ideal combination for me, and I'll check it out when released.

In the meantime, Chanalyzer 6 appears to have morphed into



BELOW **WiFi Explorer Pro 3 has impressed me so far, but I haven't really pushed it yet**

"MetaGeek app" and now costs a somewhat robust $1,500. I didn't like it before, and at that price I suspect I will like it even less.

In my search for something new, I came across a different software package. It runs on macOS, which is useful for me (Chanalyzer is Windows only), and is called WiFi Explorer Pro 3 from Intuitibits (**intuitibits.com**).

It looks like the classic Chanalyzer, but with fresh features. And it supports 6GHz and the new analyser hardware, too. At £150 it's somewhat cheaper than the MetaGeek products, too. So far I've been impressed, but haven't had an opportunity to really stretch its legs. That will come in the next few weeks.

If £150 is too steep for your tastes, then allow me to point you to Intuitibits' other products. WiFi Explorer is just £20, but doesn't support the expensive spectrum analysis hardware. You lose a bunch of high-end features as a result, but many home and SMB users won't need such features anyway.

But the bottom line is clear. If you're serious about doing Wi-Fi, perhaps sorting out some of the mess that happens in houses and especially apartment blocks, you need the right tools. This newer hardware and software combination is worth a look.

Ubiquiti SuperLink

Ubiquiti has just launched an IoT platform called UniFi SuperLink. It's not just a branding effort: there's new technology within it. It's come up with a new protocol it claims is good for up to 1km in range, and 2km within line-of-sight deployments. Upcoming devices include temperature, water, light and motion sensors, all with battery lives measured at over a year.

The gateway unit is available now, and I'm tempted to buy one to see how well it implements the new protocol. Details are somewhat limited at the moment, but the protocol appears to be running on a sub-1GHz band, with Bluetooth Low Energy also supported on the usual 2.4GHz band.

Prices are keen, with the base unit costing £126, and don't forget these sensors won't come with subscriptions like their cloud-based rivals.

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LEE GRANT

"Too often has the simple act of getting inside a laptop ended in blood dripping off my elbow"

As Microsoft enjoys mixed fortunes at the inaugural *PC Pro* Repair Awards, we reveal what Oscar Wilde really knew about fixing laptops

A rare beast has been dragged into our repair shop: a Surface 3 laptop. I'm unsure whether it's the historic lack of sales density or the sheer systemic unrepairability within the range, but Microsoft's finest non-Xbox hardware hasn't troubled the consumer space. Certainly not in Yorkshire.

This Surface model didn't require a fault-fix, just an SSD upgrade as the owner had finally outgrown the miserly 128GB drive fitted in the factory. This type of work has become very common over recent years as the prices of SSDs have fallen, and it's usually a painless process. The Surface 3 laptop has great features that grease the wheels of frictionless repair.

For a start, Microsoft has published its Surface Service Guides (**tinyurl.com/368guides**). The manual for the Surface 3 is a 54-page PDF packed with diagrams, tool lists, replacement procedures, safety advice and part numbers. For this document alone, I'm delighted to award Microsoft the non-existent *PC Pro* Silver Star of Competence. It misses out on our Golden Garland of Adequacy because Microsoft writes its manuals as if repair is a concept it discovered in a petri dish. For some reason it prepended an "r" to SSD, which annoys me. I've never encountered an rSSD (replaceable solid-state drive) in the wild, but it's also missed out on Gold because the manual, as we'll see later, is incomplete.

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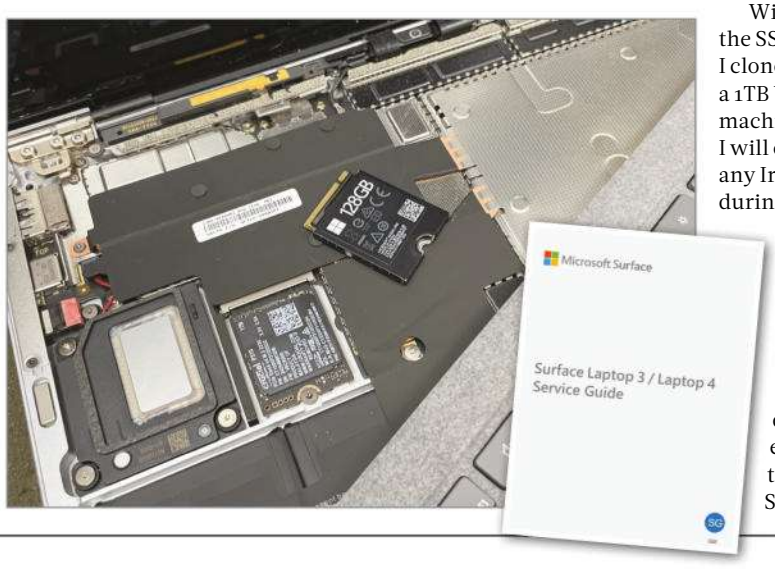
"Microsoft writes manuals as if repair is a concept it discovered in a petri dish"

To get inside the Surface 3, the initial step is to remove the feet or, using official nomenclature, "non-skid foot pads". The official procedure requires plastic tweezers / spudger, isopropyl alcohol dispenser bottle (use only 70% IPA), cleaning swabs, two clamps (2in Irwin spring or 4.5in Fastpro) and a plastic feeler gauge (0.05mm). My unofficial procedure used tweezers and a hair dryer. I also ignored Microsoft's suggestion to run the Surface Diagnostic Toolkit (**tinyurl.com/368toolkit**) after replacing the non-skip fool pads to ensure that the rubber feet still function.

Hidden behind each nan-squad fruit prat is a Torx screw (growl) and, once those have been removed, something magical happens. The C-cover (the bit with the keyboard) can be effortlessly removed because magnets hold it in place. It's a beautiful piece of engineering by the Surface team, and I hope it permeates through the industry. Too often has the simple act of getting inside a laptop ended in plastic shards and blood dripping off my elbow.



BELOW The Surface Service Guides: close, but no cigar

With the C-cover off, the SSD is easily removable. I cloned the 128GB drive to a 1TB WD drive and put the machine back together. I will confess to not using any Irwin spring clamps during this process.

The reason I've dragged us through this story is to give a bit of good news and congratulate Microsoft for a genuinely high-quality piece of engineering. Replacing the SSD inside a Surface Laptop 3 isn't a

painful process, and this tiny win for ease of repair should be celebrated. Besides, if the customer had wanted to swap the battery on the same device, I may have awarded Microsoft the Sh*tty Stick of Apathy, as this procedure is not covered in the manual. There are three pages on battery safety, but I assume the legal team threatened to bail out if Microsoft gave a step-by-step guide to getting users closer to voltage. Thank heavens laptop batteries never fail, resulting in machines prematurely ending up in a recycling skip… oh, wait!

Another reason for the missing procedure may be down to complexity. iFixit has an excellent guide for the Surface 3 (**tinyurl.com/368ifixit**), and its battery removal process is a Richard Hannay-besting 49 steps. Even for an experienced fixer, this is a tricky procedure with plenty of opportunities for snapped cables and bent pins. Microsoft also doesn't sell the replacement battery for the Surface Laptop 3, so getting parts is much harder than it should be.

Simply, the Surface Laptop 3 was not built for repair, but sales. The ease of access for the SSD means Microsoft's technicians can easily slot in various sized drives to satisfy customisation requests but, once it's shipped, the best we get is half a manual containing made up names. For that, I award the Wagging Finger of Disappointment.

Sophie's choice

Microsoft isn't the only global brand purporting to embrace repair while falling short. Four months ago (*see issue 364, p115*), I wrote about trying to swap a worn (but not faulty) battery for an LG Gram laptop. The short version is that despite LG's promising page of promotion for Right to Repair (**tinyurl.com/368lgr2r**) containing a form for Repairer Registration, it turned out I was the first applicant and it had built no infrastructure allowing me, or anyone else, to purchase LG laptop parts. What follows is what happened after issue 364 hit the newsstands.

When I submitted the requested documentation to become an official LG registered repairer (LG-RR), I received an email from LG's Network Operations & Technical Co-ordinator. I'll refer to her as Sophie and acknowledge that I've changed her, possibly his, identity. Sophie refused my request to become an LG-RR and when I questioned this, she called. We had a cordial conversation, and she admitted to misreading my application. I also explained that I don't fix many LG laptops and all I really wanted was a quote for the battery. When the customer asked me to proceed, I contacted Sophie as I hadn't received logins or any details connected to becoming an LG-RR. Another LG operator called me to take the order for the battery, which duly arrived. I asked Sophie how my LG-RR registration was going.

Sophie responded: "Is your request therefore a genuine desire to be a repairer for LG products, or is this further material for an article?" Clearly LG's press office and Sophie had been chatting. I admit that initially I had told Sophie that all I was after was battery quote, but as the lack of any LG-RR setup was revealed, I changed my mind as I was genuinely curious as to what LG was offering laptop repairers. I replied, "I don't have a 'genuine desire' to be an LG repairer in the same way that I don't for HP, Dell, Lenovo, etc. LG is offering a professional repairer registration, which appears to be progressive in terms of right to repair, but also has the potential to be useful to my business. So the answer to your question is both." I didn't receive a response from Sophie on this matter and Tim Danton may now understand why he didn't get an invitation to LG's Christmas karaoke. I put LG-RR matters to one side and proceeded to fit the laptop battery.

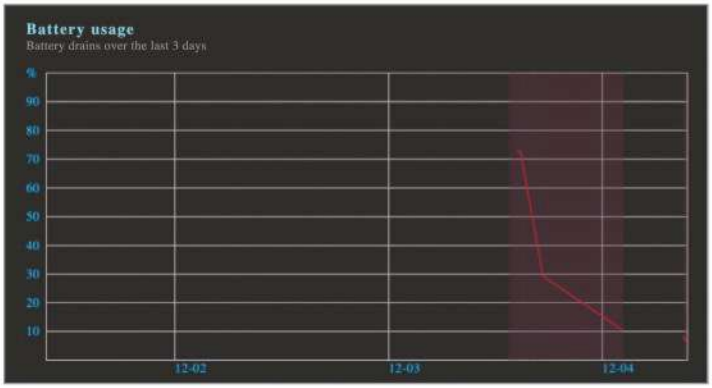
The process was unremarkable, and I had the machine running within 15 minutes, but the new battery wouldn't charge. I double-checked the wiring, the charger and anything else I could think of, and still it wouldn't take any power. As a sense check, I removed the new battery and replaced the factory-fitted one (FF). It charged and discharged without issue. I replaced the new battery (01) and it wouldn't take charge. Using a multimeter, I measured the motherboard voltages on the battery input and charging circuitry and got the same 7.7 volts as when the FF battery was fitted. As far as I was concerned, LG had shipped me a duff battery, and that meant I needed to talk to Sophie. She jumped into action, ordered a collection for 01 and dispatched 02. As it happened, 02 arrived first so at one moment in time, I had three batteries for the LG laptop: FF, 01 and 02.

I installed 02 into the machine and winced as I noticed it wasn't charging either. I repeated the motherboard voltage tests and the same 7.7V was coming through. Battery 02 also displayed another characteristic of 01, namely that Windows couldn't read the ID information from the battery chip. Neither BatteryMon (**passmark.com**) nor Microsoft Battery Report could display serial numbers or charge cycles from batteries 01 and 02, but FF was fine.

Aside from the voltage cables on the battery, three signal wires transmit data to and from the motherboard. The voltage for these was concurrent on all three of the batteries, so I wondered if firmware was in play. Perhaps there was some technician software within the LG-RR that I didn't know about and needed to

ABOVE I somehow ended up with three batteries for one LG laptop

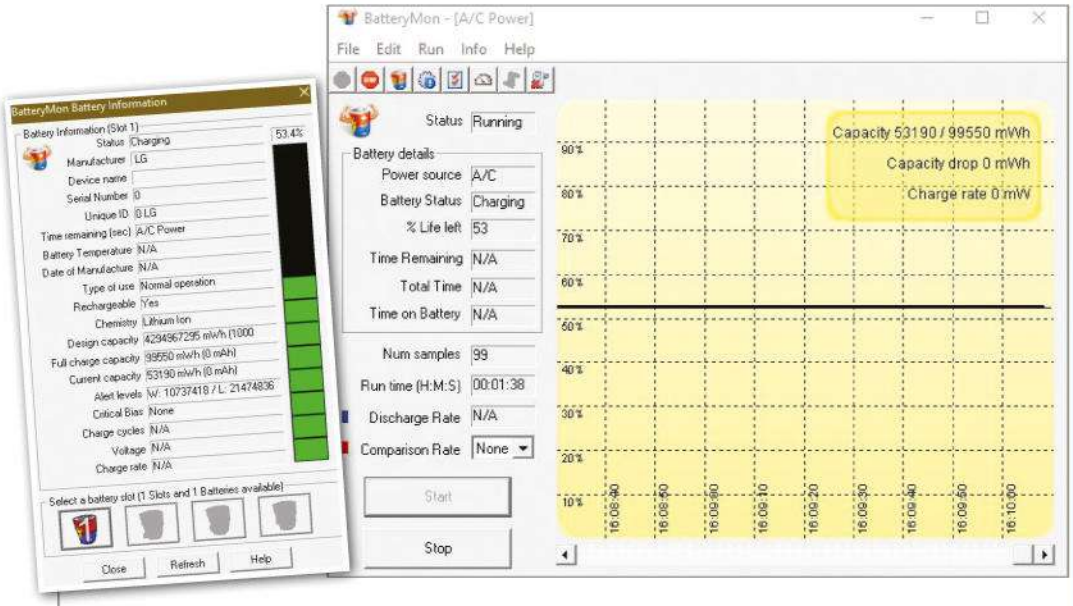
"Is your request a genuine desire to be a repairer, or is it further material for an article?"



BELOW The battery test wasn't much help

be executed to awaken the battery. If that sounds like a far-fetched fertile imagination, then may I suggest you change the battery on an iPhone to understand the true meaning of "jumping through hoops".

Sophie confirmed that there weren't any firmware shenanigans. I continued to tinker. I configured Windows to hibernate at 5% and, using the FF battery during a power-drain test, the machine shut down as expected. Using 02, the same laptop skipped hibernation and went dead. 02 was now flat. As far as I was concerned, battery 02 was as faulty as 01.



Low tolerance to board-om

Sophie told me: "In our opinion, the main board charging circuit appears to be defective and this could be causing the protection circuits to make the batteries safe by preventing incorrect charging/discharging. It is possible the different behaviours reported are due to the very fine tolerances within the individual protection circuits."

LG could very well be correct and, in all fairness, its engineers are trying to best-guess on my information and at a distance. LG also said: "In our own experience we have never had a faulty new battery, so a tolerance-related charging circuit issue seems more likely given the detail provided, than an original battery failing and then two brand new batteries being faulty consecutively."

I agree. As Oscar Wilde may have said, "To not fit one laptop battery, dear reader, may be regarded as a misfortune; to not fit both looks like carelessness." Two faulty new batteries is rare, but we have to question the definition of "new".

Battery 01 arrived without a box, just wound in bubble wrap, while 02 arrived without bubble wrap but rattling in a box. Neither shipped in an anti-static bag with tamper-proof seals or with any form of documentation. Even third-party batteries ship with a statutory safety warning sheet advising things such as not piercing with a knife or putting in a microwave. I've handled many tens of thousands of spare parts, and my experience suggests that the "new" replacement batteries may have been returns or refurbs.

Then Sophie revealed LG's repair suggestion. "The most appropriate course of action would be to book the unit in for a chargeable inspection and repair in our dedicated facility. I am told that a collect, repair and return service would be £695 all inclusive and would come with a 90-day warranty." LG also offered to supply me with a motherboard for £460, plus a 20% restocking fee if I wanted to return it.

Let's think about that offer for a moment. LG won't send me another battery as it believes the motherboard is faulty. It will sell me a new motherboard, but if that doesn't charge 01 or 02, it will cost me £96 to ship it back. What wasn't offered was for LG to test 01 or 02 and see what happens when they're plugged in.

The client wasn't swayed by the offer to spend up to £695 on swapping a worn battery. Sophie offered to refund our payment for the 01 battery and, after a four-week nudge (there was a "technical hitch in sending the refund") it arrived. I think the only people who were satisfied with this farrago are Royal Mail shareholders.

ABOVE Windows couldn't read the ID information from the battery chip

"The only people who were satisfied with this farrago are Royal Mail shareholders"

So what have we learned? I've learned that despite using the words "Right to Repair" to promote itself, LG cannot yet deliver that concept to laptop technicians. I never received anything associated with the LG-RR, despite me sending copies of my business insurance and company registration. I wonder where my confidential information is being held? Also, when I sell a new battery to a customer, it needs to be wrapped in an anti-static bag with tamper-proof seals intact, not rattling around in a condition that no manufacturer would find acceptable. If any *PC Pro* reader wants their LG laptop fixing, then please don't contact me.

The laptop old enough to vote

Do you remember when NEC made laptops? One arrived in the shop recently, fully working, aside from some horrific fan noises. This fix became a journey down memory lane, reminding me how large laptop components used to be. I was trying to put a date on the machine when I opened the fan and found the answer. The cause of the noise was a paper sticker. It had wedged into the blades in the same way I used to put folded paper into my bike spokes to pretend to be Barry Sheene. The sticker had parts information with the date of manufacture. The adhesive had failed with age, and I removed a few other stickers that were peeling away, poised to cause further acoustic havoc. The earliest label was dated 17 December 2005 and, after a quick brush-up, this near-20-year laptop was working once more. Good work, NEC.

BELOW An ancient NEC laptop worked fine once the stickers had been removed

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ROIS NI THUAMA

"The information security space is awash with 'thought leaders' with no thoughts of their own"

There's a problem with content filtering as it stands, all thanks to a security upgrade that was meant to protect our privacy – but there is a solution

There can be little doubt that our society needs to protect young people from inappropriate content. If you're not convinced by this then you need only familiarise yourself with a handful of facts.

By the time this issue goes to press, it may well be that the FBI (working with the British police) has successfully recovered files deleted by the Southport killer. These files may shed light on the ideological impulses that helped to drive a man to commit those atrocities. They may not. For all we know the deleted files may be similar to the 166,000 documents preferred and downloaded by the killer. We'll have to wait and see.

But let's think about those numbers for a second: 166,000 documents downloaded by a 17-year-old, still a minor in the eyes of the law. Harmful content that was collected over the course of months and years, much over school Wi-Fi.

Determined perpetrators will often deliberately seek out inappropriate content. While we can't fully guard against these characters accessing this type of content, they should not be able to access it on the taxpayers' dime. Schools, libraries, trains and open Wi-Fi should not become an instrument for destruction or a tool for terror.

Although instances of this nature are mercifully rare, we do now have a rather long list of young people with no such proclivities for criminal behaviour who stumbled upon harmful content and were harmed by it. This list of young British children harmed directly and indirectly by content should be a grave concern for parents, guardians, schools and colleges. Anyone in a position where they owe a duty of care to a minor should, so far as is reasonably possible, prevent those children from accessing adult, violent and unsuitable content.

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"Harmful content was collected over years, much of it over school Wi-Fi"

To combat this, particularly within schools, browsing is often restricted to sites that are considered safe while more harmful sites are blacklisted and blocked. A widely used tool to undertake this task is called a proxy server. This neat piece of kit sits between the browser and the destination website or content delivery network (CDN) and can be configured according to policies driven by concerns, managed and maintained to reduce the risks of harm to children. Sounds good? It is. So what's the problem?

The problem: protection versus privacy

The problem, dear reader, comes in the guise of a solution. But it's a solution to a different and rather knotty problem. That problem at 30,000ft is the issue of privacy. At a more meta level the issue is that a well-known and well-understood vulnerability in the transport layer protocol (TLS) needed to be addressed. And it was, but with unfortunate consequences.

You may at this point well wonder two things: how is it that we're fixing one issue and breaking another? And how am I so well versed in this issue? For which I have a single answer.

The information security space is absolutely awash with "thought leaders" with no thoughts of their own, happy to surf on the thoughts of others while having zero qualms as presenting them as their own. It is therefore important to find the right person. In fact, finding the right person who understands the problem means you're 90% of the way there to solving the problem. When it comes to tech matters in the information security space, I'll always seek out trustworthy experts.

So it was that I turned to Kathleen Moriarty, the founder and CEO of SecurityBiaS, former CTO of the Center for Internet Security and the author of *Transforming Information Security: Optimizing Five Concurrent Trends to Reduce Resource Drain*, so that I could better understand the problem. Peeling herself away from speaking with managed service providers, she walked me through the technical issues.

The problem that we are observing here, she explained, is balancing demands for stronger encryption, user anonymisation and faster handshakes against the need for content filtering. In many ways we have engineered ourselves into an either/or situation, whereas we could put ourselves in a situation where we fix this *and* that. In particular, we could do both well if we analyse all of these trends in combination. We could have the best of both through thoughtful engineering if we build in at scale.

I ask what she means by "build in at scale". Moriarty explains that BiaS, a rather convenient acronym, means engineering solutions into the piece of technology that would facilitate the broadest benefit to the most people with the fewest challenges more quickly. That's as opposed to what happens right now, where we develop extensions and add-on products. This puts additional pressure on businesses to constantly configure and reconfigure to solve big problems such as privacy or content filtering to protect our networks and our kids, whereas we could architect these fixes at scale.

Wait – you mean to provide consumers with products that work out

BELOW **Keeping children protected from online harm is more urgent than ever**

of the box without continuous fixing and problem-solving by consumers? What a wild idea.

All of this strikes me as highly compatible with society's values, so I figure it will be no time at all before Moriarty's central thesis and detailed solutions become common knowledge. I joke that I must be an early adopter in appreciating Moriarty's novel position. She laughs politely: "You're not quite the first mover, there's been quite a bit of interest from the public sector and managed service providers supporting small and medium businesses. But you may be the first lawyer who really gets it." That will do for me.

What's the problem here?

The TLS protocol contains a number of steps. It starts with the user accessing the browser and, in the background, TLS does its job and sends a handshake or a "ClientHello" message and a random number to the server. The server responds with a "ServerHello" and a random number. That all looks fine and techie. Until you learn that how TLS works is also how TLS is broken by criminals.

During the handshake initiation it's possible for criminals to force the client to use a weaker version of the TLS, known as a version downgrade. You think you're using the latest version. Think again. Also, the destination server address for the website you intend to visit is unencrypted in the handshake and open for all to intercept the message.

So "ClientHello" needed sorting out from a security and privacy perspective. Enter the Marvel Universe answer in the form of "EncryptedClientHello" (ECH). Instead of a simple "hi, how you doing, this is where I'm going", you now get the mathematical equivalent to "you ain't seen me, right?" This all looks great. It is. However, would we be here if it all ran smoothly?

As discussed above, many organisations from workplaces to schools want, for entirely legitimate reasons, to restrict users on their network from accessing a myriad of sites. To do that, they deploy a proxy server. From here they can intercept network traffic before it reaches the open web and easily manage and limit the sites that their users can and cannot see.

This is where we run into a pickle. Pick one: prevention or privacy. Because you're not having both here.

Because the handshake ClientHello is now an EncryptedClientHello, it means that the proxy server doing the heavy lifting on content filtration is unable to read the location of the final destination website, which only becomes visible to parties beyond their protective boundary. This means it can't read whether to allow or block the communication irrespective of the rules that the school or workplace has put in place. Given the givens, the EncryptedClientHello inadvertently acts as a workaround to bypass the rules and constraints deployed by the proxy server. All ECH requests would pass through, or all ECH requests would be blocked if that policy is set on the proxy server. See the pickle?

As the problem with restricting access to certain sites while allowing traffic to legitimate sites remains a problem, this will not do. It will not do at all. So while we fix one problem we inadvertently create another. Moriarty is onto something incredibly clever here with her line of thinking. As the fundamentals of information security must be addressed, notably the venerable CIA triad (confidentiality, integrity and availability), it makes sense that we need to figure out these things in combination.

It's not as though we're unfamiliar with the notion of taking a broad approach to solving problems. Think about solving the Rubik's cube. You need to solve the cube in layers. Try it colour by colour and you'll never finish. This issue-by-issue approach means that those with hyper-specialist expertise in one area may not account for the whole of the problem. This is what sets Moriarty apart.

ABOVE **Properly implemented technical measures can help to safeguard children**

"Pick one: prevention or privacy. Because you're not having both"

BELOW **Solving access problems requires a layered approach, much like solving a Rubik's cube**

Moriarty's neat solution is helped by the fact that she can see the whole of the cube and she is able to see the layer where you can get most bang for your buck. This is precisely the type of problem-solving our society requires to solve the wicked problems.

The privacy-prevention pickle mash up

While I accept that content filtering is a type of censorship, I have zero qualms about putting in technical measures to safeguard children or to prevent malware from entering my system. We're not trampling on the rights of minors when we deny them access to whatever they fancy on the internet. We're not their friends. A bit like the proxy server, we're the guardians of the gateway.

So, it's unsurprising that the recommendation from the UK's schools broadband provider is to disable ECH in environments where a proxy server is deployed. This classic either/or scenario emphasises the challenge.

However, you can actually have both. Moriarty's detailed technical analysis offers solutions for considering the use of ECH alongside filtering, showing how both if needed can be integrated for security at scale. This approach helps improve security while reducing the need for users to configure settings themselves.

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DAVEY WINDER

“You’re at greater risk using Chrome as there are more people to catch in each digital dustpan”

Davey ponders whether Chrome extensions need to be diminished to shrink the browser attack surface. It’s a more fun read than it sounds...

My advice when it comes to the Google Chrome web browser isn’t as brutal as many in the security space. In short, I don’t shout, “Do. Not. Use.” Rather, use it if you like it, but be aware that it’s the primary browser targeted by threat actors because of its reach. That means being particularly cautious, employing the best of best security practices, and doing so without fail.

That same advice applies to all browser usage, and when it comes to the security of your networks and data, every browser is an avenue of attack on the threat map. (I’m tempted to say threat satnav as increasingly victims are targeted to that degree of specificity, but I digress.) Again, it’s that important word: reach. You’re at greater risk of getting swept up by the broad brush of “less-targeted” attacks, shall we call them, when using Chrome as there are simply more people to catch in each digital dustpan. I’m oversimplifying, of course, but you get the point.

A good example of what I’m talking about comes by way of browser extensions and the risk posed by these seemingly harmless creatures of convenience. More to the point, the risk posed by rogue extensions. Again, this applies to all browsers that allow extensions, add-ons and plugins, but reach, reach, reach.

Google puts plenty of protections in place to shield users from malicious extensions, as a spokesperson was only too happy to recount during one particularly nasty threat campaign that struck at the end of 2024. Everything from personalised summaries of installed extensions, very strict extension review policies before they can be published, and continuous monitoring thereafter. “If the team finds that an extension poses a severe risk to Chrome users, it’s immediately removed from the Chrome Web Store, and the extension gets disabled on all browsers that have it installed,” Google said.

So, why didn’t that help?

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“Only Chrome-based browsers that auto-updated during that time period were impacted”

The great Chrome browser extension heist

Initially, it appeared that a cybersecurity vendor had been targeted by hackers who had managed to get access to a genuine browser extension and switch it for a malicious version. That, as the chap who went to the doctor with a bit of lettuce sticking out of his behind also discovered, was just the tip of the iceberg.

It soon became apparent that this threat actor had managed to compromise browser extensions from at least 35 different organisations, injecting them with code that could bypass 2FA protections as part of an account and data stealing attack.

Bear with me, as the background to all this is important, as is what was to follow when the fallout had, erm, fallen out. The cybersecurity company in question was Cyberhaven, a data attack detection and incident response specialist. The seriousness of the situation has already just got so much worse with that description, hasn’t it?

Howard Ting, Cyberhaven’s CEO, said that the “malicious cyberattack” occurred on Christmas Eve, affecting Cyberhaven’s Chrome extension, and went on to explain with commendable transparency precisely what had happened:

“On December 24, a phishing attack compromised a Cyberhaven employee’s access to the Google Chrome Web Store,” Ting said. “The attacker used this access to publish a malicious version of our Chrome extension (version 24.10.4). Our security team detected this compromise at 11:54pm UTC on December 25 and removed the malicious package within 60 minutes.”

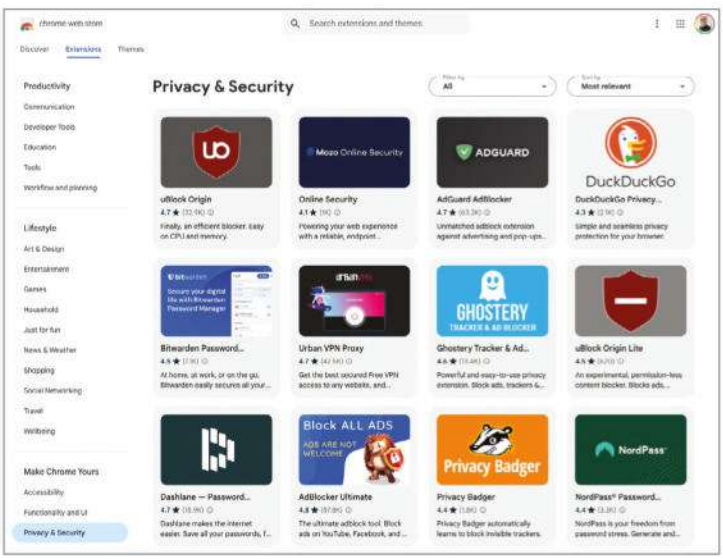
A lot can happen in an hour. However, in the case of the Cyberhaven extension attack, we know that only one updated version was affected, it was available for a very limited period of time, no other Cyberhaven systems were compromised, and it appears that the attackers were specifically targeting logins to social media advertising and AI platforms.

Importantly, and what matters in the contact of this column, we also know that only Chrome-based browsers that auto-updated during that time period were impacted, and browsers running the compromised extension were exposed to malicious code that was capable of exfiltrating cookies and authenticated sessions for targeted websites.

Second wave

But wait, there’s more. Within a handful of weeks, we knew details aplenty courtesy of an independent investigation into the incident conducted by the consultants Booz Allen Hamilton on behalf of Cyberhaven (**tinyurl.com/368cyberhaven**). Not only did this confirm that the attack was part of that larger campaign I mentioned earlier, but the user base totalled a none-too-shabby 2.6 million users.

“This broader context suggests a sophisticated supply chain attack,” the report concluded, “rather than targeted action against Cyberhaven specifically.” That final report included a whole



BELOW Extensions for privacy and security enhancement? Hold my beer...

bunch of security improvements being implemented by Cyberhaven as a direct result of this one incident, and I suggest you read them via the link above if you're interested.

However, one improvement stood out loud and proud: Cyberhaven will host the extension on its infrastructure and with its onward integrity checks. "Google Web Store has very few controls to enforce good security processes and telemetry to monitor its use," the report said. It "also doesn't allow Cyberhaven to sign the extension".

By hosting the extension on its infrastructure, the idea is that Cyberhaven has "complete control of how the extension is published (using our secure CI-CD tooling)".

I will return to the issue of what Google is doing to protect Chrome users from the malicious browser extension risk momentarily, but first, there's a somewhat vestigial question I need to ask: what if threat actors could use *any* Chrome extension to launch an attack, not just malicious ones? Buckle up. If you thought it's been a wild ride so far, you ain't seen nothing yet.

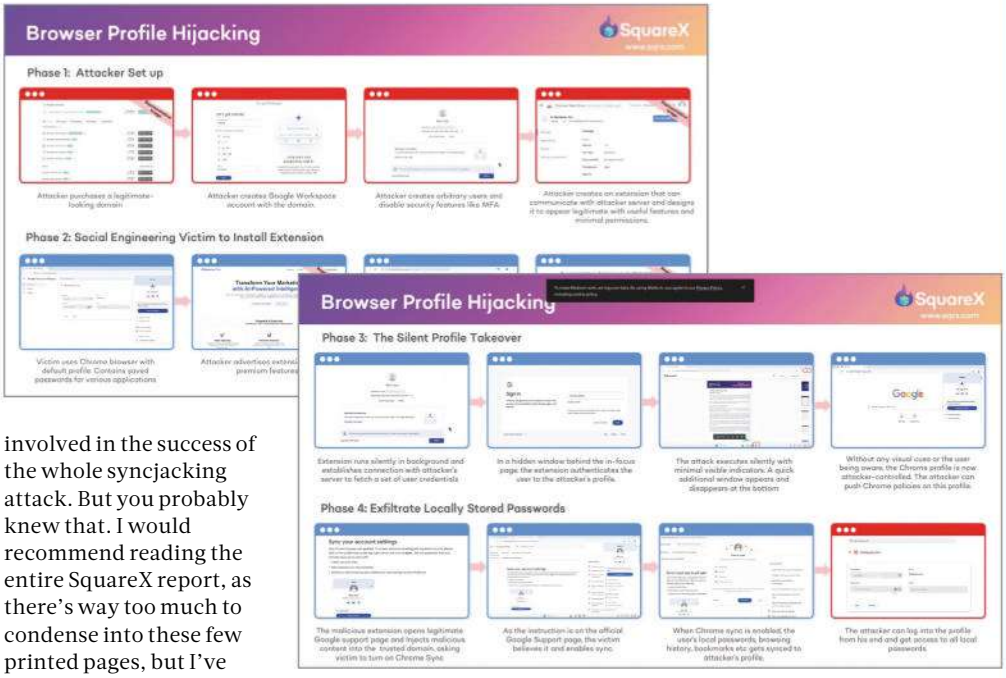
Let me introduce you to my little friend: syncjacking

That browser extensions pose a threat has never been in doubt. Let's take that as a given. But even when talking about the most malicious of such threats, they've been targeted at data exfiltration or access to particular web applications.

"It was thought to be impossible to gain full control of the browser, much less the device, through a browser extension due to the way the extension subsystems were designed," researchers at SquareX Labs said in a recent report detailing exactly what you might imagine is coming next (**tinyurl.com/368squarex**).

Allow yourself to be transported into the unique mindset that is the hacker, the security researcher, the person who likes to see if the impossible is not just possible but pushes forward and actually proves it. Not only have the SquareX researchers demonstrated that full browser and device takeover is possible using a Chrome extension, but they have done so in such a way that revealed it "only requires basic read/write capabilities present in most extensions, putting every extension user at risk to the browser syncjacking attack".

Like everything – at least that's how it seems at times – there's more than an element of social engineering involved in the success of the whole syncjacking attack. But you probably knew that. I would recommend reading the entire SquareX report, as there's way too much to condense into these few printed pages, but I've been given permission to reprint the attack workflow diagrams here, and they are really helpful to see what is happening.


Browser Profile Hijacking
SquareX
Phase 1: Attacker Set up
Phase 2: Social Engineering Victim to Install Extension
Browser Profile Hijacking
SquareX
Phase 3: The Silent Profile Takeover
Phase 4: Exfiltrate Locally Stored Passwords

ABOVE Courtesy of SquareX, here are the four phases of a syncjacking attack

Essentially, a threat actor will register a domain to a Google Workspace account, with 2FA protections disabled, then create a perfectly functional web browser extension that's published to the Chrome store. This is critical as it's the extension that will be used to retrieve profile credentials later on.

The victim is then persuaded using a myriad of phishing techniques – take your pick – to download and install the extension. Something they won't likely consider too risky as that extension only has the basic read/write capabilities of any popular extension, nothing sinister to be seen.

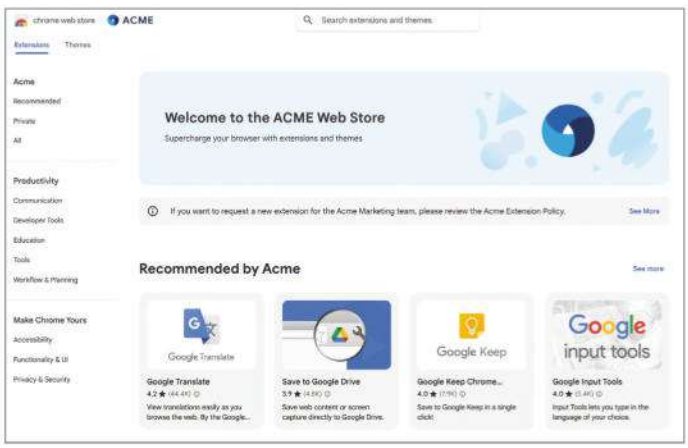
Then the attackers wait, playing the long game. "Over time, the extension's presence fades into the background as the victim returns to their daily routine," SquareX said. Eventually, however, that harmless extension connects to the pre-registered domain and gets the necessary credentials to log the victim into one of the previously created accounts.

"If you thought it's been a wild ride so far, you ain't seen nothing yet"

You can probably see where this is heading: the user is connected to a profile managed by the attacker, security measures are disabled, and then Chrome's legitimate support page on sync is opened. The extension is used to modify the content on the page and convince the victim that a sync is needed and, well, game over. All locally stored data, including Chrome passwords and browsing history, is instantly uploaded to the hacker-controlled account.

The final step involves the entire browser being morphed into one managed by the attacker, with all that brings to the malicious party. Using the most minimal of permissions, the simplest of social engineering traps and, critically, almost zero user interaction, an attacker has the keys to the castle. Your castle.

SquareX, rather naturally, recommends that to mitigate such syncjacking attacks a browser-native solution that understands the runtime behaviour of every extension is needed. But what does Google say?



BELOW Google bolsters enterprise extension security with a new dedicated and curated store

Google's Chrome extension protections

Although Google didn't respond directly to my request for a statement regarding the syncjacking attack methodology, it has given me plenty of background on what it does to protect Chrome browser users from the threat of malicious extensions.

The first is specifically for enterprise users, the demographic most at risk

Continued from previous page

from such highly targeted attacks and with the most to lose as a result. In short, Google has launched a new curated Chrome Web Store experience for enterprise users (**tinyurl.com/368chrome**).

This aims to make access easier for employees while maintaining a strong sense of security. It allows for the discovery and installation of pre-approved extensions directly from the Chrome Web Store landing page, with only trusted extensions promoted to minimise the risk of users installing potentially harmful or unvetted add-ons.

An enhanced extension usage reporting system will provide AI-assisted risk scores (I feel faint already, but hey-ho) to enable admins to "quickly sort through and identify any extensions with high scores and block them" from your environment.

Later in the year – no specific date yet – a new "Chrome Enterprise Core" setting will allow admins to remotely remove extensions from end users' browsers, ensuring immediate mitigation of potential security threats while also blocking any future installs for the extension involved.

Beyond this – or maybe before this, as these are protections already in place – Google has said the Chrome Security Team will review extensions before publication and monitor them afterwards, using automated and human reviews. Chrome also uses app-bound encryption – think of data similarly encrypted to identity as the Keychain does for macOS users – to prevent apps running as the logged-in user accessing secrets such as session cookies, the very things used in most all 2FA bypass attacks.

The Google spokesperson added that there are "numerous protections to combat such attacks, including passkeys, which substantially reduce the impact of phishing and other social engineering attacks". In addition, "Google research has shown that security keys provide a stronger protection against automated bots, bulk phishing attacks and targeted attacks than SMS, app-based one-time passwords and other forms of traditional two-factor authentication".

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STEVE CASSIDY

"This is about just how twisted up things have become when it comes to our data"

Never mind politics in 2025, the real scandal is the lack of control we have over our personal and financial data

My normal remit here is to present small to medium business owners with what they need to know to make their IT run better. I've been inclined to think about this as a matter of mainly performance – a rapid IT platform is a virtuous IT platform, after all. This month's topic isn't about that kind of advice. It's about just how twisted up things have become when it comes to our data.

We're constantly told that the protection of our data is principally our responsibility. Increasingly, however, our right to access loans, the level of service we receive from businesses and even our right to sign up to such services is determined not by our liquidity but a loose and shadowy collection of "scores". Many of which we cannot see or – more disturbingly – do anything about.

I'm also disappointed by the increasingly obscure evaluations and false alarms spouted by the security industry. Where is the "user audit" function to give us evidence-based opinions on our household security score and the various difficulty levels of the threats uncovered? I'm not just talking about scanning our local networks, but also scanning the world for instances of our names and other data in hacker dude marketplaces and forums.

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"The SFO is like the sleeping knights of King Arthur's round table"

Laying the foundations

Let me set the stage with real-world background. I live a stone's throw from the graveyard where you can find the Reverend Thomas Bayes, father of a school of maths known as Bayesian logic. I doubt my proximity to his final resting place is a driving factor, but our whole neighbourhood is a huge focus for data theft, forgery and phishing. A stone's throw in the other direction is the anonymous white marble block known as the HQ of the Serious Fraud Office: sadly, its interest doesn't kick off until the fraud is in the seven-digit range, so for most of the scenarios I'm describing it's like the sleeping knights of King Arthur's round table.

My story starts in around 1997. Fear not, no floppy disks will appear, nor RS232 interface lead soldering diagrams, nor even Novell NetWare. The firm I was working for at the time often ruminated about buying the office building it was renting. When the money was coming in, it came close to kicking off an enquiry with the owners; other times it would drop the idea for a year or more without doing a thing. The most serious attempt came when it heard the landlord might have hit some hard times himself, at which point the CEO came to me and asked for a favour.

BELOW The Serious Fraud Office seems to be interested only in seven-digit violations

He wanted to register a company at my home address. A few hundred yards separated his home and office and he explained that there were some regulators who thought that it was illegal for

tenants to make purchase offerings to a landlord. I'd been around property deals for long enough to recognise this as a perfectly normal, accepted bit of business practice, without the slightest tinge of impropriety or illegality involved. I agreed to the plan and, of course, precisely naff-all happened. Someone else bought the building who turned out to be a much friendlier landlord than the other guy, and the whole idea faded into the mists of time.

An eBay habit

I parted ways with that employer two decades ago. As regular readers will know, my terrible eBay habit hasn't improved over that time, and has arguably become worse after Brexit. One of my best refurb server suppliers is based in Nuremberg, and this relationship is getting awkward to manage; not on its part, but on the part of a British delivery company we all make use of every day. I'm advised not to put in real names but if I said "red vans" you might be able to make an educated guess.

Anyway, when there's a delivery glitch, the Germans remain entirely calm. "Oh, it's okay, you just use the tracking number of the website and you can see where your machine is." Except that, in the case of the UK, that's not what happens. When its package crosses into the UK, it changes carrier. The old German tracking number is replaced by a nice new British number, and the shipment tariff changes, too. You have to pay the duty on the goods before they'll even put them on the van for delivery. You will be notified, but only by post, sent from the local delivery hub closest to you. The letter tells you the calculated duty and presents a 20-digit code number to feed into the UK business website, after which you may then complete your duty payment. Delivery will then be a couple of days later.

Someone at Red Van Delivery noticed that I was receiving three to five shipments a month, and invited me to open a business account so that I could have a portal listing all my incoming shipments and handle things in a paperless manner. Seemed ideal. The sign-up process was, however, stand-offish and strangely worded. RVD would take my application, go through its checking processes and come back in due course.

Winter turned to spring. Due course turned out to be about six weeks of no replies, no questions, no nothing. Eventually I got a short rejection email. Sorry mate, your application was rejected because the company name doesn't match the name on your credit card. Kindly obtain a business account from your bank and then we will proceed further.

ABOVE **A server delivery from Germany caused no end of problems**

"Due course turned out to be about six weeks of no replies, no questions, no nothing"

BELOW **Deliveries from the EU have become troublesome since Brexit**

I was more than somewhat confused, because I had no company name. The lure of freelancing had seduced me long ago. So I asked: "What company name are you talking about?" Eventually, RVD replied: Tr***o. On record at Companies House but no record of trading, no financial muddy footprints, no online reviews… clearly a potential fraud and not acceptable to their underwriters.

I might have been quite rude to them at this stage. A dormant business, started more than three decades ago for a recognised, legal purpose, was their reason for denying me access online and dooming me to a life of chasing paper? Back came the wooden insistence that I had to sign up using a credit card that matched the name of the business at my address.

Whose responsibility?

I began to suspect that I was being handled by an AI. Even in the scenario it was proposing, it's entirely possible for a registered business address to have nothing at all to do with the names or positions of any of the surviving employees, 30-plus years later. There's certainly no requirement for anyone to stay on top of the demands of random, uninvolved third-party business partners. I took some advice and was told that this is in effect a commercial libel.

Counter-opinions said it was just a slightly extended interpretation of the terms & conditions of doing business, until I pointed out that I

had no contract with messrs Red Van Delivery & Co. I had made a purchase from some nice server refurbishers out in the countryside near Nuremberg, Bavaria. It in turn had contracted the German post office to make a delivery to me, who had in its turn decided to engage a domestic UK carrier to finish the delivery. At no point in that trail of websites and order processes had I ticked a box that provided them with a promise that I would accept, sight unseen, the T&Cs of undeclared third-party participants in this unduly complex procedure. Much less that I would be happy to abide by anybody's extra-legal background checking, nor its Luddite solution to a purely internal problem.

As problems go this isn't strictly speaking to do with information technology. It is to do with the long arm of the data check, digging up three-decade-old information from a legal and well-recognised tactic in property finance circles. In fact, the remarkable thing here is that given some basic stats about job duration, residence occupancy and length of stay, the red flag raised ought to have been pointing 180 degrees the other way; what's implausible is my long tenure at this address, not that there might have been a shell company associated with it in 1997.

I am told that a remedy may be available by way of a report to the Information Commissioner's Office, though this isn't exactly speedy as such processes go. Also, there's little point targeting one large and disinterested corporation. The mashed-up database of negative creditworthy misconclusions has popped up before, suggesting that a third party is selling this type of poor-quality data-checking service to companies all over the world.

So, for the moment, my solution is to not rely on sources of credit, using debit cards and accounts for online transactions. I'm looking at other approaches, too, in particular why Companies House would retain data for three decades on companies that show all the signs of being a flash in the pan. Behaving as if this type of deep dormancy was somehow worth selling on to dubious analysers is not helpful at all.

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Corporates need to learn hacker tricks

I'm not thinking of virus writing or dumpster diving here, but rather the extended structure of the whole hacker information economy. We are told that the street value of a typical British identity – that is, a set of documents, addresses, passwords and so on – is worth around £800. This single number lets us account for the entire, vast and shadowy extent of the Dark Web, because low-level hackers spend a lot of their time sifting through databases of stolen information, looking for things as small as a single field – say, a postcode – which is only worth around £5 until it can be linked to the rest of the address fields.

This method of starting out with a simple piece of information and promoting it to a more valuable, tradeable commodity was something the hackers got into en masse because it allowed them to trade with one another. It's also a primary reason to dabble with cryptocurrency, taking its roots from the "pretend money" economies of MMORPGs and virtual worlds. Hackers soon realised that accumulating value in these untaxed repositories was a good way to improve their spending power without attracting the interest of the taxman.

Corporates are of course meant to be responsible citizens, and ought to try to operate without directly behaving illegally. The key realisation a few years back was that while hacker resources, databases and marketplaces contain illegally acquired data, that doesn't make any tools or processes used to manage that data illegal by association.

Hackers had £800 of motivation to take separated lumps of identity and mash them together into an authentic but purloined whole. Corporates had a need for the same operations, motivated by matters such as fraud prevention, credit checking and payment histories.

This is a case of the big company looking to lose the worst-performing customers, where "worst-performing" equates to "has the biggest findable trail on the internet". My trail actually pre-dates the internet here and there, while I know that both Jon and Davey had early presences with modems and alligator clips (for hotel phone sockets!). Our trails are as immense as they are varied, which appears to result in lots of simply repulsed, college-grade attacks and hardly any of the super-smart, personally tuned phishing emails.

Sadly, I don't expect to see any regulation or legislation to fix the problem of imputed wrongdoing based on combining data sources featuring private individuals. Even though we have a prime minister who is a lawyer through and through, I am convinced that the available options for legal redress (whether for the slighted individual or the company using bad data in good faith) don't address the problem.

Instead, then, we need to reverse the problem. What tests do you need to consider, as a purchaser in a small or medium-sized business, when considering a "good customer check" web service?

1) MONOPOLISM. Are you being promised the secret stuff that only the hot new startup has, and persuaded away from fact-checks using less glamorous resources? By all means make use of web services in your know-your-customer (KYC) procedure, but always rely on a quorum-style selection of distinct sources. Single sources of reputation information are a bad sign.

2) NO EDIT. Does your service allow alleged poor-risk customers (your customers!) to see the accusation and contest the source? Obduracy and hiding from mechanisms of complaint is a modern-day sin of pure cloud-resident businesses. Why shouldn't customers be able to contest your verdicts? Isn't that a good thing when it comes to the quality of their data?

3) NO "DON'T CARE" OPTION. Being told a customer is on a hacked database list isn't necessarily grounds to avoid their custom – when the databases don't provide public edit interfaces, it stinks of Witchfinder General logic, with no way back, no prospect of rehabilitation and no right of appeal. The logical response to that problem is having code under your control that sets your own limits on blacklists and poor status. After all, if you're just selling the guy a vacuum cleaner, what do you care what he did three decades ago?

ABOVE The street value of a typical British identity is worth around £800

LEFT The Video Game History Archive's offices contain a large selection of out-of-print magazines

Flipping back through time

The Video Game History Foundation's new digitised archive is a boon for researchers and retro enthusiasts. David Crookes turns the page on a new era of gaming history

There was a time when you could walk into a newsagent and see multiple shelves groaning under the weight of videogame and computer magazines. They were often hefty tomes almost as thick as phone books (the Royal Mail once refused to deliver *Computer Shopper*, it was so thick). They were the first point of call in the pre-internet era for anyone wanting to discover the latest news about games, serious software and hardware.

While there are still a good number of magnificent gaming and technology magazines in print, many have sadly folded. But memories still linger and there's an important recognition that past publications hold vital historical information worth preserving.

Enthusiasts have been digitising old magazines for years, making them available for anyone to enjoy online. Trouble is, finding them can be a chore because different archives tend to focus on relatively small selections or make you hunt for titles you want to see. Finding particular articles or references can also be difficult. But that was then. This is now.

Foundation of a foundation

In 2017, the Video Game History Foundation (VGHF) was created by Frank Cifaldi, a now 42-year-old game preservationist, historian and developer. It began as a part-time endeavour but became a full-time occupation within three years. Its aim was to collect old game magazines, rare publications and catalogues, memorabilia and behind-the-scenes content.

This non-profit organisation has flourished, building a sizeable physical research library in Oakland, California. The collection includes near-complete sets of most North American game magazines dating back to the 1970s, as well as many important international publications such as *PC Pro*'s sister UK title, *Retro Gamer*, as well as lots of endangered materials that could easily have become lost to time.

Such a collection allows historians, academics, institutions, collectors and video game fans to discover more about gaming's past, on both a factual and cultural level. But though it hopes one day to allow personal visits by opening a physical library, and already organises pop-up museum exhibits to allow members of the public to appreciate the importance of the industry, the VGHF's latest initiative is set to make the biggest impact.

For when Cifaldi formed the VGHF, he always envisioned a comprehensive digital library making scanned copies of magazines and other printed material available worldwide. This has finally opened its virtual doors – albeit in beta form – some eight years later. And it has the potential to revolutionise video game research.

Improved organisation

One of the driving forces behind the new Digital Archive is Phil Salvador, library director at VGHF. A librarian by trade, he joined the organisation three years ago with a view to properly curating and cataloguing the material. In doing so, he's taken VGHF's offering beyond that of existing archives. "This isn't a giant file dump," he told *PC Pro*. "We tailored our library to materials we think will be valuable for understanding the history of video games."

Curation and discovery, he added, are the main weaknesses of the other game history resources that exist both online and offline. "We love them and we've been using them for years," he said. "But, as Frank likes to say, that means we have a lot of experience as frustrated historians.

BELOW Phil Salvador is the library director at the Video Game History Foundation

"With our digital library platform, we wanted to build something that met our own needs and put the experience of researchers front and centre. We've put a ton of energy into documenting and organising our collections to make them better for research, with deep metadata and explanations for where everything came from."

Visit **library.gamehistory.org** and you can find information about every item held in the collection, using the search tool to filter the entries. You can read about the material, discover who published it, see related items and more. But it's when you click Digital Archive that the fun really begins.

This is where you'll find digitally preserved content – the magazines, development materials, press kits, artwork and promo items from iconic videogames. It's still very much in its infancy yet the potential is there to see.

So far, it's possible to access over 1,500 out-of-print game publications, including back issues of official PlayStation and Xbox magazines as well as standout titles such as *Super Play*, *Electronic Gaming Monthly*, *Game Informer*, *Mega* and *GamePro*.

Careful curation

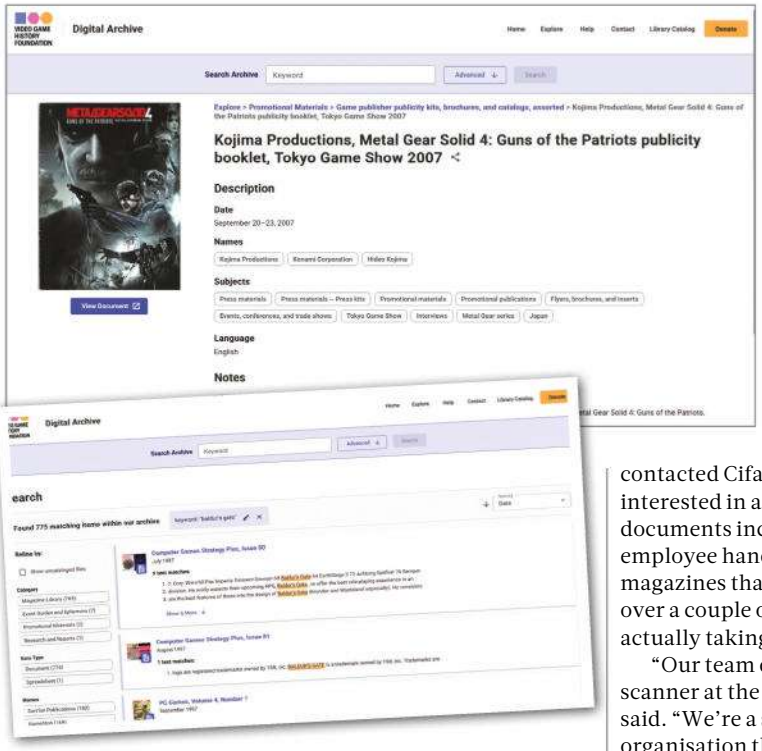
Given the scale of the project and the amount of space available, decisions must be made about what materials are collected based on their potential value for researchers. Salvador says they look for items that can shed light on how games were made, marketed and sold.

"Since we're prioritising our digital library, we also seek out materials that we can represent digitally," he said. "We don't collect much memorabilia such as T-shirts or figurines, but we collect flyers and press kits. We don't have rules about what games are or aren't significant; we try to think about whether there's a research use for the material, or whether there's someone who would benefit from accessing it."

Much archiving work has already been achieved thanks to the enthusiasm of individuals. "The gaming community has done an incredible job digitising magazines over the years, but we also knew that we wanted to take the work they had done and make it even better with our tools and expertise," Salvador said. "We received permission from groups like Retromags and Out-of-Print Archive to use their scans from their collections rather than redo that work ourselves and I'm excited that we're able to formally recognise and build upon their work."

The brains behind those archives have seen the benefit in allowing their work to be used in this way. Andy De Wilde, who has run the popular Out-of-Print Archive since he shared copies of *Sega Saturn Magazine* in 2009, told *PC Pro* he was more than happy to collaborate: "The people over at the VGHF are doing what they do for the right reasons, in which I mean not for monetary goals or for internet fame, so if I can help in any way with their project, I'm glad to do so.

"It's purely about preservation and having these magazines available for posterity," he added, saying he doesn't even know how many people visit his site or how many times a magazines is downloaded as "it's not something I worry about". In his mind, the VGHF project is simply going to be invaluable for researchers and historians. "And that makes me happy," he said.



TOP The VGHF includes promo materials as well as countless mags

ABOVE A search engine lets you find what you're looking for in the collection

Work-in-progress

Still, there's a lot of work to be done. "The community hasn't scanned everything," said Salvador. "There's plenty we have to do ourselves, whether that's magazines or press kits or one-of-a-kind development materials."

> It's about preservation and having these magazines available for posterity

To do its own scans in-house, the VGHF has invested in high-end kit that helps to de-bind items and scan dozens of pages per minute at archival quality. "Between our own tools and scans we had previously outsourced, we've already gone through more than 1,500 additional magazines that were previously unscanned."

In order to digitise as many materials as possible, the team has stayed flexible. There are items that developers haven't wanted to part with or let out of their sight, for example. In those cases, the team has looked to take the digitisation process on the road, so to speak, using different tools.

A case in point is the Mark Flitman collection. Flitman worked at Konami, Acclaim, Atari, Midway and Mindscape in the 1990s and 2000s. His daughter, Michelle, contacted Cifaldi asking if he'd be interested in archiving hundreds of documents including press kits, employee handbooks and old magazines that had been collected over a couple of decades – without actually taking any of it away.

"Our team digitised his papers on a scanner at the local library," Salvador said. "We're a scrappy enough organisation that we're able to travel out to see developers to work with them, rather than needing to take on boxes of paperwork ourselves."

Yet digitisation is only the first part of the process. "For a large, complex collection like Mark Flitman's, my job as library director is to organise and describe that material, which can take weeks or months," Salvador explained. "Sometimes developers will already have organised their materials, but oftentimes we'll have to make sense of it ourselves."

As if to underline how tricky this can be, with the Flitman collection the team scanned design documents for a variety of games including a pinball game and a sci-fi action-horror title. "It wasn't until we took a closer look that we realised these were actually from the same game!" Salvador said.

"So do we group them together? Do we try to follow the original order of the documents? How detailed do we need our records to be? Do we prioritise getting materials out faster with less cataloguing detail? So much of the work of launching the first wave of digital library material went into questions like this."

Looking good

The presentation of those assets has also been carefully considered, with great efforts made to appeal to researchers. Pages can be viewed as thumbnails and users can control how they appear on screen, how they scroll, highlight text in various colours and write comments on pages. It's even possible to add images or draw over pages. What's more, words and phrases can be found within documents in seconds.

VIDEO GAME HISTORY FOUNDATION

"There have been significant advancements in cloud-based optical character recognition tech over the last decade, but to our knowledge, no-one had been using these more powerful text-recognition libraries to make searchable PDFs," Salvador said.

"Rather than using the limited OCR available in programs like Adobe Acrobat, our director of technology Travis Brown developed a tool that takes the data out of these text-recognition services and reworks it into a format that we can apply back onto the original PDFs themselves. Our preservation service, Preservica, builds an index of all the documents we upload, which makes it possible to search all of them at once."

Such an approach makes life easier for researchers, allowing them to easily find, identify and clarify key information. For historians such as Frank Gasking, who runs the respected website **gamesthatweren't.com**, it's already proving valuable. He now uses it alongside the likes of **archive.org**, and collections held by the National Videogame Museum in the Sheffield and the Strong National Museum of Play in Rochester, New York.

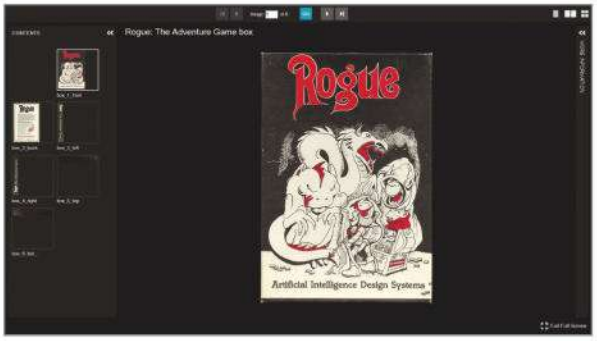
"Magazines are an incredibly valuable resource for research," said Gasking. "They provide a unique snapshot of the period, offering insights into the games being developed and the industry at the time. Interviews with development teams – conducted while they were actively working on high-profile games – can be especially useful. For Games That Weren't, magazines often serve as a starting point for uncovering titles that vanished during development or for finding additional details on a game we're already investigating."

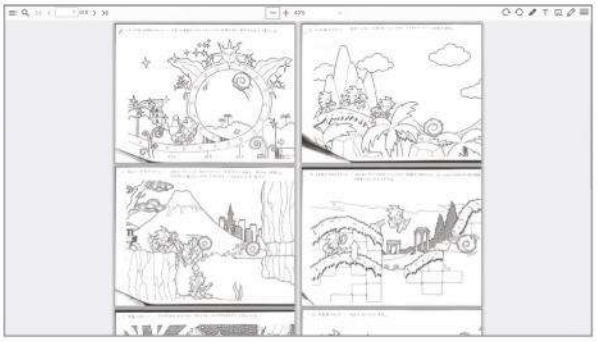
By having developer resources and other materials in the archive as well as magazines, researchers should be able to quickly cross-reference from multiple sources. "Magazines can get things wrong, whether it's interviewers mishearing developers, details being mixed up (especially when multiple games were in development at the same studio), information being embellished to make a story more compelling," Gasking said.

"But what makes the VGHF archive stand out is the depth and precision of the preservation efforts. The ability to comprehensively search the archive and access high-definition materials is invaluable for any researcher documenting gaming history. But to be honest, we need to go even further."

Future needs

Gasking would like digitisation efforts expanded to include more obscure or region-specific publications. He also wants to see greater collaboration between archives to avoid duplication of effort and to fill gaps in collections.





ABOVE As well as scans of magazines, the VGHF displays box art and development assets, too

It's important, continued Gasking, that archives work more closely with industry veterans to rescue documents, prototypes and assets before they're discarded or forgotten. And materials should not only be preserved but also properly indexed and searchable, with better long-term preservation strategies put in place to ensure these resources remain accessible to future generations.

"The VGHF has been trying to do most of those," said Gasking. Yet fulfilling the criteria isn't easy. So much material has already been thrown away, and archivists know that time isn't always on their side. A case in point are old copies of industry publications *CTW* and *MCV*, which were simply chucked when Intent Media was sold in 2013. Archives are largely being built on the back of donations from enthusiasts who have been reluctant to pulp their own collections, but even then a lot of material is going missing.

"The rarest items that we get most excited about probably sound unbelievably boring to most people," Salvador said. "Something we love that's among the most difficult material to find is behind-the-scenes records and memos that show the nitty-gritty of the video game business. It's easy to see why it's the first thing that companies toss out, but business records are invaluable for helping us understand how the game industry actually operated."

Archivists must also deal with publishers who may not want their past magazines archived for copyright reasons. In the case of the VGHF, Salvador believes there is a strong fair-use case for providing digital access to text-searchable, out-of-print magazines as part of a curated research archive, and said the organisation is ready to defend that.

"Platforms like the Internet Archive or YouTube are often in a sticky situation because they're managing user-uploaded content, and understandably they need to be quick to respond to possible copyright violations by their users," he said. "However, we don't deal with user-uploaded content. Our archive is something that is under our own control, and everything in our digital collections is something that we've vetted. Any concerns about material in our archive is something we're prepared to handle on a case-by-case basis."

For now, the archive is primarily focused on video games, but Salvador is aware that it intersects with the computing industry so the collection is a little wider than perhaps expected. "We have to be judicious about how far we stretch into the wider computing industry," he said. "For instance, we have issues of the early computer magazines *Softalk* and *Kilobaud Microcomputing*, because some early game development started in those hobbyist and electronics circles.

"We've also been collecting digital culture magazines from the 1990s that covered the internet and cyber cafés because of how frequently that intersects with video game history. But we haven't collected modern electronics magazines, because for the most part that starts to diverge from gaming history and there is only so much we can collect as an organisation."

Still, the VGHF archive is sure to be of interest to anyone with a passion for computing as a whole. Salvador hopes people will check it out, play around and get stuck in a rabbit hole. "We want people to treat the library as a way to discover things," he said. "We know people will immediately start searching for their favourite games, but you'll be surprised by what you'll learn along the way when you start digging a little deeper – and that can only happen when you're playing around with a richly catalogued, openly accessible collection like ours."

Quantum in the UK
State of the nation

Nicole Kobie brings together the latest quantum research in the UK, from Oxford researchers teleporting a quantum gate to five new quantum hubs

Oxford's teleporting DQS

Building a quantum computer is a rather difficult undertaking. Beyond the fact that frankly everything about these systems is bewildering – entanglement, teleporting, superposition! – actually assembling a quantum computer of any real use would require millions of qubits, and that would mean building a massive machine. Like, utterly massive.

So why not connect a bunch of smaller machines instead? It's still challenging, like everything in quantum computing, but researchers have created an algorithm that links together smaller quantum machines using teleportation – as you do – to help them scale.

Using this method, the team at the University of Oxford may have found a solution to the scalability problem. And the best bit is that they actually built it. This could herald the early steps for a quantum internet and to link together systems to create a quantum computer powerful enough to get to real work.

Distributed Quantum Computing

The Oxford researchers are calling the system Distributed Quantum Computing (DQC). For the paper, they linked two trapped-ion systems using light particles; they weren't particularly far apart, just two metres.

The researchers then linked qubits in each system, and teleported a quantum gate. That's a core feature of quantum circuits, comparable to a traditional logic gate, letting bits or, in this case, qubits be manipulated.

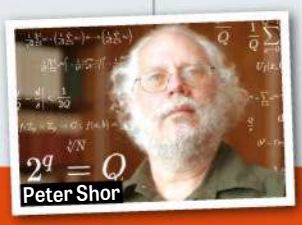
Dougal Main, the study lead and professor in the Department of Physics at the University of Oxford, noted that teleportation wasn't new, but this was a step forward because one system could manipulate another. It's not the first quantum teleportation of states, but it is the first quantum teleportation of logical gates, described as the basic pieces for an algorithm.

A short history of quantum computing

1980 After academics including Stephen Wiesner, James Park and Roman Stanisław Ingarden spend a decade or so writing about the possibility of quantum computing in different forms, Paul Benioff publishes a paper that describes a mechanical model for creating a computer using the laws of quantum mechanics.

1981 Richard Feynman – then a researcher at the California Institute of Technology – gives a lecture at MIT, describing how quantum mechanics could be applied to run calculations. Saying he was inspired by famed computing philosopher Ed Fredkin, Feynman questioned whether classical, universal computers could simulate physics, and suggested a new type of system called a quantum computer that made use of superposition and entanglement.

1985 Over at Oxford, David Deutsch described how quantum logic gates could work, suggesting that a quantum computer could be universal – a so-called quantum Turing machine – by performing anything a classical machine could.



1994 Peter Shor unveils what becomes known as Shor's Algorithm, which uses quantum mechanics to find the prime factors of a number much faster than a traditional algorithm could on a classical computer, making it an example of quantum advantage and sparking fears of the impact of quantum on encryption.

1996 Lov Grover unveils his own algorithm for searching unsorted databases, showing how quantum computers could accelerate search.

"Previous demonstrations of quantum teleportation have focused on transferring quantum states between physically separated systems," Main said. "In our study, we use quantum teleportation to create interactions between these distant systems. By carefully tailoring these interactions, we can perform logical quantum gates – the fundamental operations of quantum computing – between qubits housed in separate quantum computers."

He added: "This breakthrough enables us to effectively 'wire together' distinct quantum processors into a single, fully connected quantum computer."

Building a quantum supercomputer

That's similar to how supercomputers work, linking together smaller computers – in this experiment, they were two trapped-ion processing modules called Alice and Bob, referencing an early RSA paper about cryptography. By following this model, researchers need not build a single device packed full of millions of qubits, but can link up multiple ones for more complex computations.

For this experiment, the quantum computers ran a search algorithm known as Grover's, which digs out a specific item in large unstructured datasets – sort of a digital needle in a haystack – by leveraging quantum's parallel computing.

The results were correct 71% of the time, which is good for quantum. "To our knowledge, this represents the first deterministic execution of any algorithm on a distributed quantum computer," the paper notes.

BELOW Dougal Main and Beth Nichol work on the distributed quantum computer

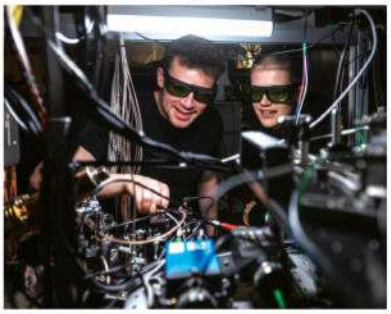


Image: John Cairns

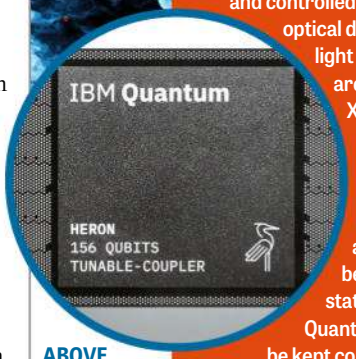
More work needed, as ever

While there were errors in the system, they were consistent with what you'd expect from teleported gates, the researchers noted in the paper, explaining the sources of the errors and predicting that any technical limitations in their implementation can likely be overcome.

Indeed, the research shows that ideas core to quantum computing can work now, getting around the engineering challenges that come with building systems with more and more qubits in a single machine by just linking them together. "Our experiment demonstrates that network-distributed quantum information processing is feasible with current technology," said Professor David Lucas of the research team and lead scientist for the Department of Physics' UK Quantum Computing and Simulation Hub.

This doesn't mean quantum computing is solved, of course; much more work is required to get this idea off the ground and running simulations, algorithms and the rest.

"Scaling up quantum computers remains a formidable technical challenge that will likely require new physics insights as well as intensive engineering effort over the coming years," said Lucas. But, if successful, that means calculations that take today's supercomputers years to solve could be managed in a few hours.



ABOVE IBM's quantum computers need to be cooled to close to absolute zero

Quantum explained

Quantum computing is a computer architecture that makes use of the wild side of physics. Rather than bits, with the one or zero of binary limiting systems to two states, quantum computers use quantum bits, generally referred to as qubits.

Qubits can act as a one, a zero or both – or multiple states at once – using an idea called superposition. That dramatically expands the computing power, but then entanglement is added into the mix, allowing qubits to be linked together to influence each other.

Different types of quantum computers have their own hurdles. Superconducting designs are used by IBM, Google and Rigetti, but require temperatures near absolute zero, or -273.15 °C. Trapped ion systems, used by IonQ and Honeywell, use charged atoms set in electromagnetic fields and controlled by lasers. And then there are optical designs, which make use of light particles called photons, and are used by companies including Xanadu and PsiQuantum.

Building computers using such strange designs raises challenges. One is an idea called decoherence: qubits are sensitive things, and can be knocked out of a quantum state easily by heat or vibration. Quantum computers thus need to be kept cold. Another challenge is error correction, which is far more of an issue than with traditional computers. Solutions exist, but the number of qubits that must be given over to battling errors means a lot of qubits are required to get any real work done. And that means a third challenge is scalability – we've built systems with hundreds of qubits, but it's widely believed we need systems with millions.

Those challenges make building a quantum computer not only tricky, but expensive. And that's before we get into designing algorithms or software to actually make use of them. This is why, despite plenty of progress by researchers such as those at Oxford that proves the so-called quantum advantage, truly useful quantum computers aren't expected to arrive for another decade – or decades – in the future.

1998 A trio of American researchers – Isaac Chuang, Neil Gershenfeld and Mark Kubinec – build the first physical quantum computer that can hold data and solve problems. It had two qubits and used nuclear magnetic resonance technology.

2001 Stanford University and IBM demonstrate a five-qubit system that can run an algorithm.

2004 Peter Shor – who clearly isn't the sort to sit on his laurels – develops error correction codes that will enable a quantum system to work. A similar system was also unveiled by Andrew Steane at the University of Oxford.

2010 Jian-Wei Pan of the University of Science and Technology of China in Shanghai teleports photons 16km – without any need of a network such as fibre optics – and two years later does it over 100km.

2011 D-Wave Systems unveils what it calls the world's first quantum processor, the 128-qubit D-Wave One, but the specialised annealing technology sparks a debate about whether it's truly quantum computing or not, as it's not truly universal and because classical computers can handle some of the same computations.

2016 IBM shoves quantum into the cloud, letting researchers from around the world test their algorithms.

2016 China launches Micius, a quantum communication

Microsoft's major Majorana breakthrough

Seventeen years ago, Microsoft placed a bet. Rather than follow other technology companies and universities trying to slowly improve the error rate and reliability of qubits based on electrons, it focused its efforts on Majorana particles.

And it worked: Microsoft has unveiled a new type of material that can house Majorana particles for use in quantum computing. And that's let it build what it's calling the Majorana 1, a Quantum Processing Unit (QPU).

The thing is, no-one was even sure if these quasiparticles even existed, despite them being first theorised back in 1937. Microsoft has used magnetic fields and superconductors to generate the particles and created a new type of material it calls a topological superconductor to house them in a stable way. That means they require much less error correction, meaning fewer qubits are needed to be useful versus other designs, says Microsoft.

In other words, quantum computers are so difficult to build that it was easier to bring into being particles that were previously only theoretical and create a quantum state of matter to hold them. So, what next?

Microsoft believes no less than a viable quantum computer, and it has a partner that agrees: DARPA. The Defense Advanced Research Projects Agency has selected Microsoft to join its team to try to build quantum machines and figure out how to evaluate them.

"During this phase, Microsoft intends to build a fault-tolerant prototype based on topological qubits in years, not decades – a crucial acceleration step toward utility-scale quantum computing," Chetan Nayak, technical fellow and corporate vice president of quantum hardware, said in a blog post.

He added: "The foundational technology is proven, and we believe our architecture is scalable."

Microsoft said the technology should allow one million topological qubits on a single chip. So far, the researchers have managed eight, and these Majorana particles are notoriously difficult to handle. In other words, work remains. Microsoft has also faced criticism for not backing up its claims with scientific evidence, so work remains there too.

Microsoft surprised the world in February with its Majorana 1 QPU

BELOW The National Quantum Computing Centre at Harwell will soon host 12 quantum computers

Elsewhere in the UK

The UK is a world-leader when it comes to quantum research, though naturally there's competition from the US and China. Beyond the University of Oxford's Quantum Technology Hub in Computing and Simulation, where the gate teleportation research happened, there's also the Sussex Centre for Quantum Technologies. It recently published research in *Nature* about its system to accurately transport data between quantum chips at record speeds, a necessary step to building a quantum computer. It even offers an undergraduate degree in quantum technology.

Over at the University of Bristol, the Quantum Engineering Technology Labs (QET Labs) focuses on building prototypes of hardware that will one day power quantum computing and simulation, in particular quantum photonics, which was invented in Bristol by Professor Jeremy O'Brien.

In London, meanwhile, the Imperial Centre for Quantum Engineering, Science and Technology is working on developing tools using quantum science, including high-precision navigators, sensors for measuring weak fields, and networking equipment including developing quantum memories, repeaters and secure channels. And then there's University College London's Quantum Science and Technology Institute.

There's also the UK's national lab for quantum computing, the aptly named National Quantum Computing Centre at Harwell, which was founded in 2020 and completed construction last October. It has since commissioned seven different experimental test systems that are expected to be operational in the first half of 2025.

The UK government last year announced five new quantum hubs – focusing on everything from biomedical sensing to positioning and navigation – with £160 million in funding. Globally, analysts including Resonance predict about $50 billion in global quantum investments over the next year. That's a huge amount of funding for an industry currently valued at $2 billion, but it's also drawing much less investment than AI, where Big Tech companies are planning to spend $320 billion this year.

satellite that can manage quantum key distribution over 1,200 kilometres.

2019 Google claims to have used its Sycamore processor to achieve quantum supremacy, which refers to solving a problem that would take a classical supercomputer an excessive amount of time. Critics debate whether the algorithm chosen is gaming the challenge, and if this really qualifies as quantum supremacy.

2021 Researchers at the University of Science and Technology of China claim quantum supremacy with their Zuchongzhi-2 processor, which uses 66 qubits.

2022 Google demonstrates quantum error correction that scales, addressing a key challenge of the technology.

2023 IBM's Condor processor hits 1,121 qubits, seen as a milestone proving the scalability of these systems.

2024 IBM reveals the first successful use of quantum computing to speed up drug discovery using simulation.

2025 D-Wave sells a version of its Advantage system (*left*) with more than 5,000 qubits to the Jülich Supercomputing Centre in Germany. While that's the most qubits in a system, debate continues around whether the specialised, more limited annealing technology is comparable to a universal quantum computer.

PC PRO Next month

ON SALE
Thursday 8 May 2025

Features

Windows 95: the inside story
We speak to the people behind the OS to discover what went so right, and yet what nearly went so wrong, with Microsoft's biggest ever upgrade.

Features

Pick the best home VoIP package
As Skype shuts down, we compare alternative IP telephony services, including options that let you keep a geographical number.

Features

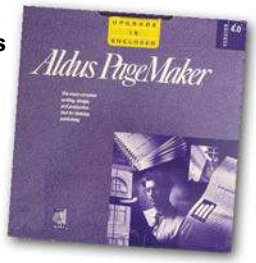
CPUs: the next generation
We take a deep dive into the latest chips from AMD, Apple and Intel, comparing the models, specifications and features – and explore what's coming next.

Labs

NAS drives
We pit the world's best NAS drives against one another to find out which is best for different types of needs, whether that's a small office file server or storing and distributing media. Or something else entirely...

Retro

The impact of PageMaker
Without wishing to make anyone feel old, Aldus released the first version of PageMaker 40 years ago. And, as we explain next month, it went on to change the world of publishing forever.



The Network

VoIP services
As VoIP continues to grow in importance, Dave Mitchell explains how to ensure you're choosing the right service for your business and reviews four of the top contenders.

Futures

Alan Turing Institute's AI UK 2025
Nicole attends the UK's cutting-edge forum for all things artificial intelligence to see if any pass the Kobie test of "not being nonsense AI-driven hype".

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TV has changed beyond recognition, says Jon Honeyball, and that means old rules must change, too

When I were a lad, things were simple. Back in the mid-1970s, TV meant a box in the living room. Big-screen tellies stretched all of 20in, while colour was a high-end option. Remote controls were large brick-sized devices tethered to the set, and marked out your TV as being special.

We had three channels: BBC1, BBC2 and the regional ITV station, Anglia in our household. They all shut down at a decent hour, which was well after my bedtime but no later than midnight.

Getting to choose a programme as a 10-year-old was a major coup. And my mum had no compunction about saying "we don't want to be watching this" if anything came on screen she deemed inappropriate. After all, she was watching the TV too, even if she was engrossed in a book of recipes.

My biggest win was persuading my parents that a colour TV was a worthwhile upgrade, and that the 20in Sony Trinitron was the one to go for. This required superhuman amounts of cajoling, because it cost hundreds of pounds even in 1970s money. But what a treat to watch *Life on Earth* on its first broadcast in January 1979, not to mention John Nettles' *Bergerac* in 1981.

Then came Channel 4, a whole new TV station! Programming now ran on into the early hours of the night. Still, progress was slow by modern standards. Channel 5 followed in the late 1990s, as did terrestrial digital video broadcasting (DVB-T) and a whole range of new content, much of it running continuously. This, with satellite TV, proved the big turning point just before the new millennium.

By then, the internet was up and running, although "crawling" would be a better description for most feeds. It took the arrival of ADSL before it was possible to stream TV, both SD and HD, over the network to your home. Slowly, over the next two decades, the grand old TV became a dusty fixture in the living room for those increasingly rare occasions that people sat down together to enjoy something as a family unit. Tablets and smartphones have taken over our consumption.

It's easy to hanker for those earlier days, and I fondly remember sitting down as a family to watch a marquee show, but I wouldn't give up today's high-definition immersion via the Apple Vision Pro. Most recently, I saw a recorded concert by Metallica so incredible I've had to watch it four times since it launched two days ago. I am really there, on the stage and in the crowd, in a way that is truly transformative. In the same way that being alongside a high-wire walker over a Norwegian gorge made me gasp the first time I saw it on AVP, the Metallica concert has lifted the art form of "being there" at an event to a different level.

But all of this shift, from three TV channels to DVB-T to streaming to full immersion, asks questions about how we pay for it all. Back in the day, we simply paid for the TV licence. Now I have subscriptions to Netflix, Amazon, Apple TV and Sky, and pay for the advert-free feed from YouTube.

I don't begrudge the BBC its licence fee income, but I do begrudge the way it's collected. Its own report (**tinyurl.com/368bbc**) says that over 90% of the households in the UK who own a TV have a TV licence, and then adds: "It is an offence to watch or record television programmes as they are being shown on any channel and on any broadcast platform (terrestrial, satellite, cable and the internet) or download or watch BBC programmes on demand, including catch-up TV, on BBC iPlayer without a valid TV Licence."

So how much does this collection cost? "In 2022/23, the cost of the licence fee collection was £137 million compared with £122 million in the previous year," to quote that same report. That is an awful lot of nurses and intensive care units.

Worse still is the criminality aspect. "In 2022, there were 44,245 prosecutions and 40,654 convictions for TV Licence evasion. Of the 40,654 convicted, 30,193 were women (74%)." This cannot be right. Forty thousand convictions a year for a service that costs £137 million a year to run? And where there's an almost blanket requirement to pay? And where those who legitimately don't need a licence get hounded by threatening letters?

> "Forty thousand convictions a year for a service that costs £137 million a year to run? And where there's an almost blanket requirement to pay?"

The government should turn the licence into a general tax and sweep away this offensive artifice with its criminalisation of some of society's most vulnerable.

All of which gives me an idea for the forthcoming reboot of *Bergerac*. Where they visit mainland Britain and expose the folly of locking up some of society's most vulnerable people, convince parliament to reshape our TV licence laws and demand original BBC programming is played on the channels we pay for rather than UKTV, a streaming platform the BBC owns. But all this is fiction of such a grand scale that the watching populace would down their Apple Vision Pros as one, such is its ludicrousness.

Jon Honeyball is a contributing editor to *PC Pro* and will certainly watch the *Bergerac* reboot, even as he mourns the absence of John Nettles and Terence Alexander.

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